APR 1 3 1956
cp

The Dock & Harbour Authority

No. 425. XXXVI | MARCH, 1956 | Monthly 2s. 6d.

UNIVERSITY OF MICHIGAN
MAR 11 1956
TRANSPORTATION LIBRARY

The Organisation with 3 Centuries of Dredging Experience

WESTMINSTER DREDGING CO. LTD.

12 · 14 DARTMOUTH STREET · WESTMINSTER · LONDON S·W·1 Tel: Trafalgar 6835-6
And at BROMBOROUGH - CHESHIRE Tel: Rock Ferry 2233-4

Contractors to the Admiralty and Crown Agents

SHIFTING SILT AT SEAFORD

LOADING GRANITE AT GLASGOW

There's a world of distance between loading at Glasgow and cruising down to Tasman Bay, and no telling what you'll come up against between the two. Except, of course, that in both places—and in most ports between—Priestman equipment will be making navigation simpler and safer; cargo-handling easier and faster.

PRIESTMAN

Manufacturers of dredging and cargo handling equipment for seventy-five years

PRIESTMAN BROTHERS LIMITED, HOLDERNESS ENGINEERING WORKS, HULL.

BCA

To Correspondents

All Letters and Contributions intended for Publication should be addressed to the Editor:—K. R. Doggett, Assoc.I.C.E., **"The Dock & Harbour Authority," 19, Harcourt Street, London, W.1,** and must in all cases be accompanied by the name and address of the sender.

To Advertisers

Our circulation is world-wide, and we have subscribers in 83 countries. For Advertisement Rates and particulars of space available apply to the Advertisement Manager, 19, Harcourt Street, W.1.

Subscription Rates

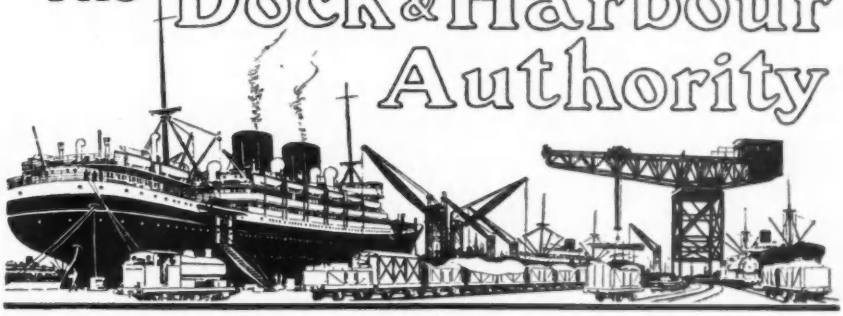
PER 2/6 COPY
(plus 6d. postage).

Annual Subscription:—
United Kingdom ... £1 10s. 0d.
Abroad ... ... £1 12s. 6d.
(post free anywhere).

All subscriptions must be Prepaid. Postal Orders and Cheques should be addressed and made payable to FOXLOW PUBLICATIONS LTD., 19, Harcourt Street, London, W.1, and crossed Midland Bank, Ltd.

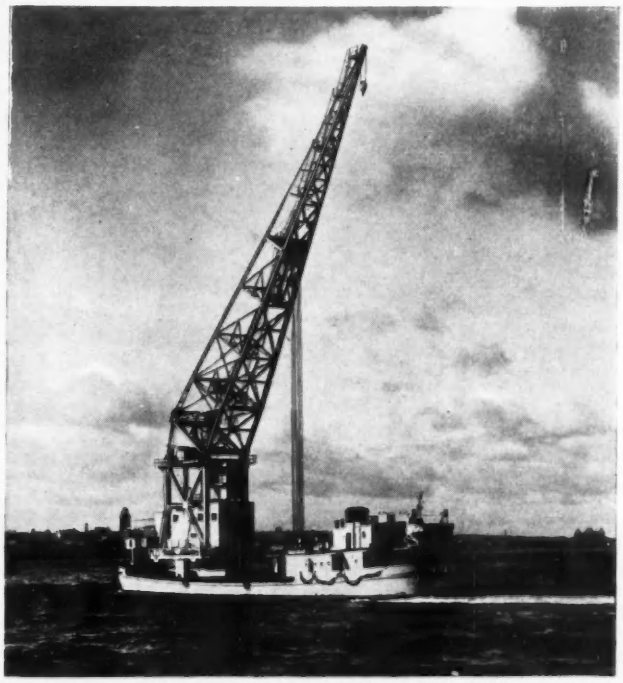
Telephone: PAD 0077 and 0078.

The Dock & Harbour Authority



CONTENTS

EDITORIAL COMMENTS	327
U.S.A. FOREIGN TRADE ZONES	328
PORT ACCOUNTANCY	331
NEW TIMBER STORAGE BUILDING	336
THE USE AND MISUSE OF HYDRAULIC MODELS	337
REMOVAL OF OIL FROM DOCK WATERS	338
THE HOPPER DREDGE	340
PROVESTENEN OIL PORT, COPENHAGEN	345
A BONDED WAREHOUSE FIRE	347
REDUCING HARBOUR SWELL AT EXMOUTH	348
SYMPOSIUM ON GENERAL CARGO HANDLING	348



This is Atlas

A 100 ton Floating Crane built by Lobnitz and now in use by the Mersey Docks and Harbour Board. The thoroughness of design, attention to detail and meticulous craftsmanship which characterise all Lobnitz products are again evident in this recent acquisition by so eminent a Dock Authority.

MULTI-BUCKET DREDGES—SUCTION DREDGES—DIPPER DREDGES—GRAB DREDGES—HOPPER BARGES—ROCK BREAKERS—HARBOUR CRAFT

Lobnitz THE NAME TO REMEMBER IN DREDGING

LOBNITZ & CO LTD RENFREW SCOTLAND RENfrew 2216 London Office 55/61 MOORGATE EC2 MONarch 5101

LILLIPUT

modern dredging equipment

★ **BUCKET DREDGERS—MODEL BV.**

The model **BV** is suitable for dealing with almost any kind of soil. The dredgings can be discharged to either side, or if required to both sides simultaneously through long or short chutes.
The buckets which are of special design have a special discharge ridge fitted to the inside which facilitates the discharge.

★ **BUCKET DREDGERS WITH DISCHARGE PUMP-MODEL BP.**

A **BP** is also a bucket dredger, but equipped with a discharge pump. The pump forces the dredged mixture through floating and fixed pipe line to the dumping point.
BP's are eminently suitable for jobs necessitating the dredging of widely divergent types of soil and for spanning great distances of discharge.
This type of dredger has a funnel, a grid and as far as the larger machines are concerned, a fully automatic soil cutter.
Fairly low and modern superstructure.

★ **SUCTION DREDGERS-MODEL ZP.**

A **ZP** suction dredger can only be economically exploited for the dredging of sand.
Sand which might otherwise not be suitable for being dredged by suction dredger can still be dealt with if a high-pressure force pump is installed. In such cases the dredger also proves less sensitive to sand with some admixture of clay or loam. The soil which is sucked up is also, as in the case of the **BP** models, passed through the discharge pump and forced through pipe line to the shore. Diesel-mechanical or electric drive.

★ **CUTTER-SUCTION DREDGERS-MODEL ZC.**

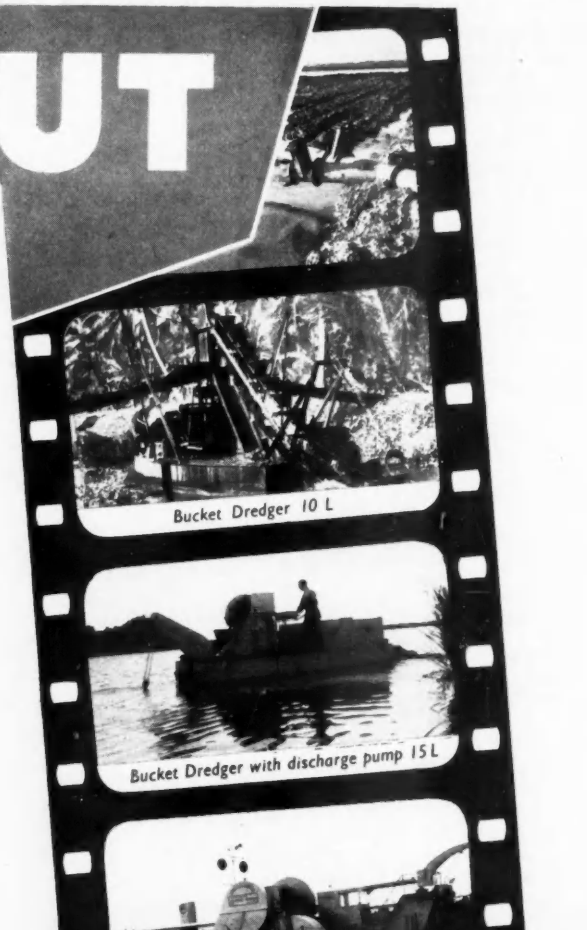
A **ZC** Cutter suction dredger is essentially the same as the **ZP** dredger, but in addition it is equipped with a cutter-installation. The shape of these cutters varies greatly. They consist of rotating knives, sometimes fitted with saw-teeth; the so-called "Crown" shape is also used. Soils suitable for this dredger are sand, peat and clay or mixtures. For each kind of soil we can construct the correctly shaped cutter.

★ *world wide service*

SOLE MANUFACTURER:

B. P. de GROOT.
WEESP—HOLLAND

Cables: "LILLIPUT."


Bucket Dredger 10 L
Bucket Dredger with discharge pump 15 L
Bucket Dredger with discharge pump 200 L
Suction Dredger pipe Φ 150mm.
Suction Dredger pipe Φ 450mm.

Sole Agents for Great Britain: HOWARD & DENNIS, LTD., BEDFORD ENGINEERING WORKS, BEDFORD.

The Dock & Harbour Authority

An International Journal with a circulation extending to 83 Maritime Countries

No. 425

Vol. XXXVI.

MARCH, 1956

Monthly 2s. 6d.

Editorial Comments

The March Issue

We regret that, owing to the continuance of the dispute in the printing industry, we are experiencing difficulties with type setting, and are again compelled to curtail the number of pages of text in this issue. The leading article, describing the extension and official opening of the Apapa Whaf, Lagos, Nigeria, which was planned for this month, has had to be deferred, together with other articles, but we hope they will appear in April. We appreciate the tolerance of our readers and advertisers in our present straits and hope to be able to resume normal publication shortly.

U.S.A. Foreign Trade Zones

The subject of Free Ports, or Foreign Trade Zones, has frequently been referred to in these columns. Although there are free ports in some European countries and in the Far East, they are not in favour in the United Kingdom where the system of Bonded Warehouses, in which goods can be manipulated under Customs supervision, seems to satisfy the requirements of the re-export rtade.

Free Ports are, however, finding increasing favour in the U.S.A., and an article on a following page in this issue gives details of the facilitiies available at five of the principal ports in that country, where a reasonable degree of success appears to have been acheived.

The present article emphasises the advantages of Free Ports from the American point of view, but even in the U.S.A. the subject is controversial, as the number of ports that possess an area of land which is technically fit for conversion to a Foreign Trade Zone is limited. It will be remembered that a Free Zone was proposed for Boston in the 1930's but the suggestion was found impracticable. Also, the Foreign Trade Zone started at the Port of Mobile in 1938 was unsuccessful as it was discontinued a year or so later.

American Port Construction Activity

It is interesting to note the signs of intense activity and competition now existing in American Ports, particularly in the eastern half of the country. Two major influences appear to be at work simultaneously. One is the increasing prosperity of the United States as a whole, with an expectation of £4,800 millions worth of exports, and an import figure of £3,800 millions. Never before in times of peace has so much trade been handled at the ports, and there is every sign that American business men do not regard this trend as being in any way ephemeral. On the contrary plans are going forward for increasing port capacities to accommodate an even bigger trade.

The other stimulus is provided by the commencement of the St. Lawrence Seaway project. As is well known, this project was strongly opposed by the Eastern Seaboard Ports, on the grounds that the penetration of ocean-going ships into the heart of the continent would deprive them of trade. Nor were the railways serving the Eastern ports disinterested. Now however that the legislation for the seaway is completed and the work begun, the Eastern Seaboard Ports are anticipating the competition which will arise shortly with Great Lakes Ports, and are actively planning improvements and modernisations.

The New York Port Authority has announced schemes for a major overhaul of the Brooklyn waterfront estimated to cost £50 millions, closely followed by a £2 million scheme for extension of the Port of Newark. Philadelphia, the second largest port in the country has recently started a campaign with the avowed intention of becoming the biggest port in the world. The Pennsylvania Railroad is active in this direction as are the oil refining interests. Again the Port of Newport News is receiving much publicity through the efforts of the Chesapeake and Ohio Railway to stimulate foreign trade through that port. There are also a number of smaller schemes for improvement which have been approved or are under consideration at other ports. It is hoped to publish details of the more important schemes from time to time in this Journal.

All in all the picture is one of intense activity on the Eastern Seaboard, no doubt with the intention of capturing as much trade and goodwill as possible before the St. Lawrence Seaway becomes an accomplished fact. But there are signs that, a thousand miles to the west, the Great Lakes Ports are also becoming more active. The first announcement comes from Chicago, where work has already started on a scheme to make the port an international one capable of handling the largest deep sea ships which can make use of the Seaway. Developments at other Great Lakes Ports can be looked for.

All this activity is to the good, provided it fosters healthy competition and reduces the cost of carriage by sea. It remains to be seen however, whether the tremendous, one might almost say unruly, economic potential of the United States can remain for a long period on an even keel and so justify the considerable outlays which are now being made on port construction.

Port Accounting

During the past few months, this Journal has received enquiries concerning accountancy problems connected with the port industry. This is an aspect of port working which appears to have received little publicity and, to the best of our knowledge, there is a paucity of literature on port accountancy procedure. We therefore propose to publish, from time to time, articles dealing with various features of the subject and the first of these appears in this issue.

There is such a diversity of port undertakings that many accounting problems affecting one port may not be of concern to others, so that a compilation of a general character is difficult, as it would have to cover such a wide field. The author of the present article is dealing exclusively with management accounting and has mentioned only one of several possible methods, all of which have something to be said for them.

The larger ports already have, of course, their own systems for recording their financial transactions and therefore do not need further guidance. This may not apply, however, to many of the smaller ports abroad, not to the junior members of accounts departments who are still gaining experience and therefore will be glad of the opportunity of further instruction.

We hope that the article in this and the following issue will stimulate interest. Further contributions and correspondence on the subject will be welcome.

U.S.A. Foreign Trade Zones

Review of Facilities and Services

(Specially Contributed)

Free ports have been in existence in Europe since the fifteenth and sixteenth centuries and have since been established throughout the world. The first free port, or Foreign Trade Zone in the U.S.A., however, was established in 1937 at the Port of New York, and since that date four more foreign trade zones have been established at the ports of New Orleans, San Francisco, Los Angeles and Seattle.

The principle upon which a zone establishment is justified is that until merchandise enters the country of consumption, it should be free of duty and customs charges. It follows, therefore, that no country should restrict the freedom of merchandise which has not applied for customs entry. The purpose of a free zone is to provide a haven where goods may be held, prepared for market, and traded whilst they hold their separate status and privileges as foreign merchandise not yet subject to the import laws of the country. At this stage there are no duties or taxes to be paid and there is freedom, within reason, from customs and other governmental regulations not necessary for the protection of the revenue, public health or safety. The zone makes available to transit goods the freedom they require, provides storage and facilities for reconditioning imported goods destined for eventual consumption and acts as a marketing centre.

The Foreign Trade Zone is described as a fenced-off, Customs guarded area where, with a minimum of customs control, foreign and domestic merchandise of every description may be stored, sold, exhibited, broken up, re-packed, assembled, distributed, sorted, graded, cleaned, mixed with foreign or domestic merchandise and otherwise manipulated or manufactured. The merchandise may be re-exported, destroyed or sent into Customs territory in the original package or otherwise. It is subject to Customs duties if sent into Customs territory, but not if re-shipped to foreign ports.

General facilities such as labour, guard services and fire protection are common to all five zones in the U.S.A. In addition to the boundary fence and floodlights for protection, there are sprinkler systems, extinguishers and central alarms. Adequate watchmen and guard service on 24-hour duty combine with Customs patrol officers, within the area and at the gates, to protect against fire, pilferage, loss or damage to cargo from any preventable cause. Cargo insurance rates are therefore reasonable. Special rooms and cribs under double lock and automatic alarm protect valuable and pilferable cargo.

Charges made for storage and for handling in and out of storage are largely based upon the size and weight of packages. In the case of bulk commodities charges are usually upon a short ton basis. Especially valuable commodities which require special storage and handling are charged on the basis of value. Supervisory and labour charges are on the basis of per man hour and are assessed only when manipulation or special services are requested. Rooms or processing areas are leased usually on a monthly basis at a specified rate per sq. ft.

Foreign Trade Zone No. 1—New York

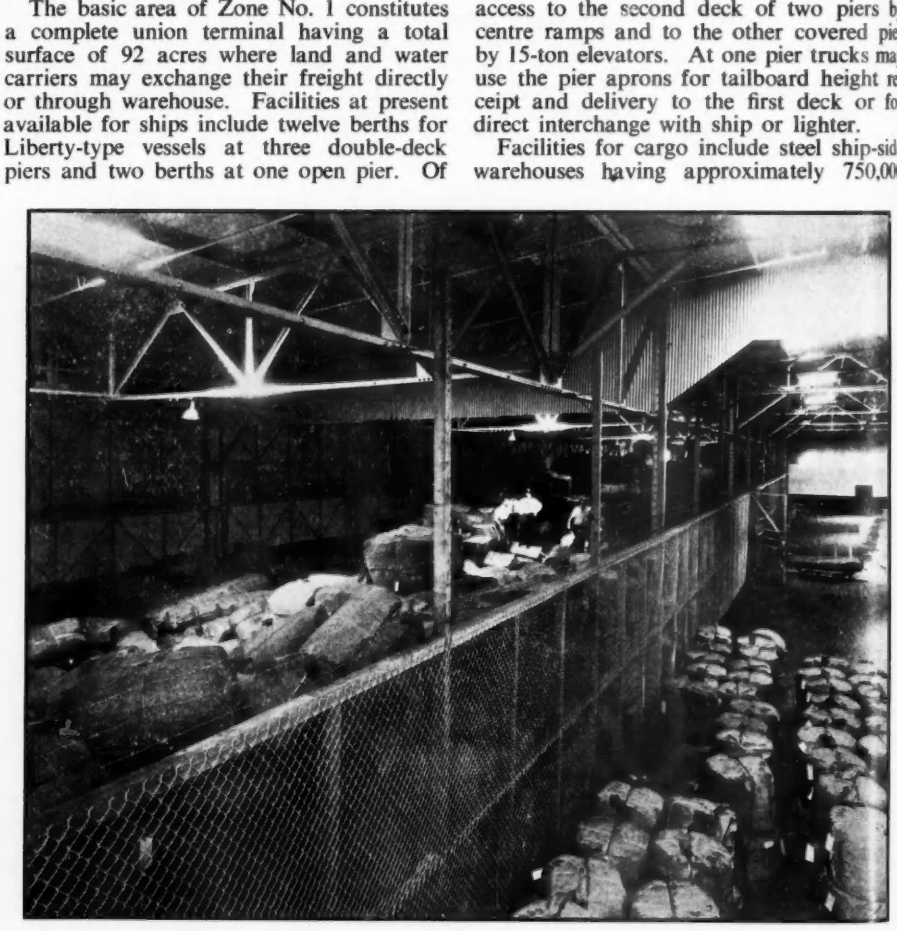
The New York Foreign Trade Zone, which is operated by a private company, New York Foreign Trade Zone Operators, Inc., on behalf of the City of New York, has an enviable location close to the main ship canal as it enters upper New York Bay. Situated at Stapleton, Staten Island, within the City and Port of New York, the Zone enjoys the advantage of being at the centre of one of the largest ports in the world. Vessels daily arrive and depart from and to almost every country in the world and it is possible for any one of these vessels to berth at the Zone or to exchange cargo with the Zone by harbour craft or motor truck when berthed at another pier within the Port.

The basic area of Zone No. 1 constitutes a complete union terminal having a total surface of 92 acres where land and water carriers may exchange their freight directly or through warehouse. Facilities at present available for ships include twelve berths for Liberty-type vessels at three double-deck piers and two berths at one open pier. Of these berths, two are served by apron rail tracks and four have semi-portal gantry pier cranes with a lifting capacity of up to five tons. All except the berths at the open pier are rigged for burtoning. Water and electricity are available at all the covered berths. Bulkhead berthing for harbour craft totals nearly 2,000 ft. and is served by two 75-ton stiff-legged derricks, marginal rail tracks and roadway.

Rail facilities include two apron tracks with cross-overs on the north side of one double-deck pier for ship to rail exchange. Every pier is served by rail at bulkhead. There are 22,650 ft. of sidings on the upland for classification, storage and service purposes. These connect with the Baltimore and Ohio Railway System and interchange with all trunk lines serving the Port. In addition, floats and railway lighters serve the Zone, which is within the free lighterage limits of the rail heads.

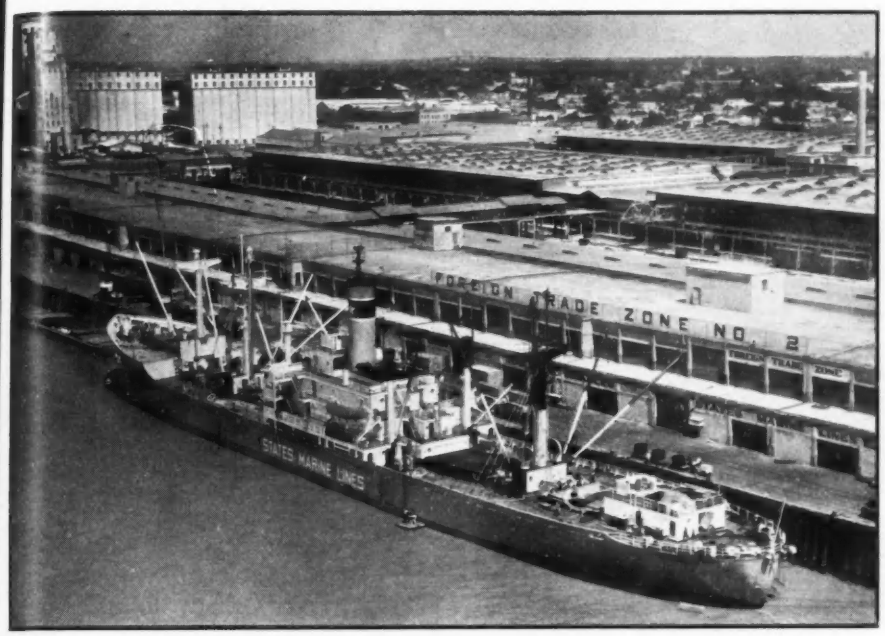
Trucks serve the area over a marginal street and a transverse street and have direct access to the second deck of two piers by centre ramps and to the other covered pier by 15-ton elevators. At one pier trucks may use the pier aprons for tailboard height receipt and delivery to the first deck or for direct interchange with ship or lighter.

Facilities for cargo include steel ship-side warehouses having approximately 750,000



Foreign Trade Zone No. 1, New York. Privileged domestic merchandise in Custom Crib

U.S.A. Foreign Trade Zones – continued



Foreign Trade Zone No. 2, New Orleans, covers an area of 20 acres.

sq. ft. floor area with 16 to 24 ft. storage height at 300-500 lb. per sq. ft. Numerous office, manipulation and special storage rooms and cribs are provided in these buildings. The upland behind the piers at present comprises about twenty acres, hard-surfaced for open storage purposes. Constructed on the upland are roads, rail tracks, a tobacco warehouse and a tobacco auction building, the gate house and administration building and a large building suitable for storage or manufacturing purposes. There is also available a modern warehouse providing about 60,000 sq. ft. of storage area and special manipulation rooms. The Zone's land and water barrier has a length of approximately 7,000 ft. and there is a photo-electric light beam to protect the water gateway.

Foreign Trade Zone No. 2—New Orleans

New Orleans Foreign Trade Zone is located on the right ascending bank of the Mississippi River, about 110 miles from the Gulf of Mexico. The wharf provides 1,008 ft. of berthing space, parallel to the river bank and 45 ft. width of apron in front of the wharf buildings, which total 725 ft. in length. Modern equipment has been installed, including electric cranes and two electric elevators as well as several large marine cranes which can be made available for handling heavy lifts. Ships may be fuelled with coal or oil from colliers or barges moored offside vessels at the wharf, or may be tied up at the bunkering wharves in the port proper. The Zone is owned and operated by the Board of Commissioners of New Orleans Port.

Costs for storage, handling, processing or special services are worked out on the same basis as those for the New York Foreign Trade Zone. There are also auction rooms, display and processing space together with the modern facility of a fumigation chamber. Incidentally, no other Gulf port has a fumigation plant.

Foreign Trade Zone No. 3—San Francisco

The San Francisco Foreign Trade Zone, which was given its charter in 1948, is within easy reach of the industrial heart of the area served. It is situated on Pier 45, at the western end of the Embarcadero, opposite the famous Fisherman's Wharf, and is the first commercial pier reached by ships after passing the Golden Gate. The Zone provides 810 ft. of berthing space, permitting four ocean-going vessels to be berthed simultaneously. There are no special facilities for mechanical loading or unloading of ships, but when "heavy lifts" are being handled, derrick cranes or trucks are used or floating heavy lift lighters. Other equipment such as fork lift trucks and power trucks are available on a rental basis.

There is approximately 169,000 sq. ft. of open storage space available in the Zone and 281,000 sq. ft. of covered area. Two enclosed areas containing approximately 2,000 sq. ft. each are reserved for manipulation and, in addition, there are several rooms which may be used for either manipulation or exhibition. There are refrigeration facilities available with a capacity of some 36 tons.

The Zone is served by inland waterways and coastal vessels and spur tracks are served by the State Belt Railroad which connects with the main railway lines of the area. The Zone possesses a safe for the added protection to precious stones and other highly valuable articles.

Foreign Trade Zone No. 4—Los Angeles

Foreign Trade Zone No. 4 is situated in the Outer Harbour of Los Angeles at Berth 60, Municipal Pier No. 1, and includes all of Municipal Warehouse No. 1, consisting of 72 rooms with a total of 477,580 sq. ft. Altogether there is some half-million sq. ft. of covered storage space and 50,000 sq. ft. of open storage space. There are also twenty large rooms available for rental as offices and display rooms as well as for manipulation. The six-storey concrete warehouse is fire-proofed and protected by sprinklers.

Foreign Trade Zone No. 3, San Francisco. Pier 45 and four large sheds, left foreground

U.S.A. Foreign Trade Zones—continued

There are two shipside rail tracks on the wharf apron and an arcade over two depressed rail tracks. Four railway lines, operating as a unified belt line, serve the whole port. A concrete railway on the east side of the warehouse connects with the Harbour Boulevard and permits truck carriers to operate from each storeroom at tailboard height.

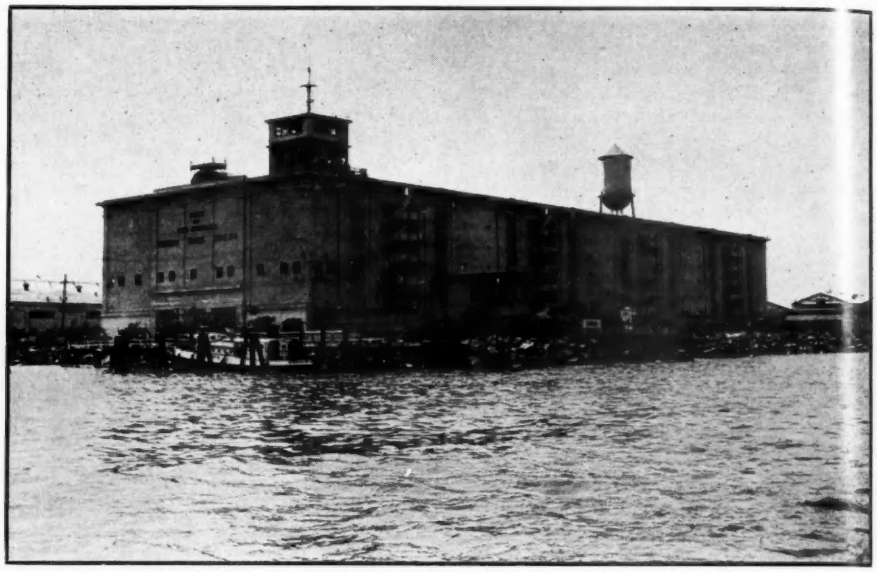
Foreign Trade Zone No. 5—Seattle

Established in 1949, Seattle's Foreign Trade Zone is at East Waterway Terminal. It comprises over 350 lineal ft. of deep-sea vessel berthing space, equipped with locomotive cranes, mobile cranes, fork lift trucks and all necessary cargo handling equipment. There are two covered transit sheds, totalling 51,000 sq. ft. of storage space. Rooms and security lockers are available for the examination, sampling or manipulation of merchandise. There is no open storage area but there is ample space for manufacturing and public exhibition.

The Zone is served by four trans-continental railways and can connect with world route airlines through the Seattle-Tacoma Airport. It is operated by the Port of Seattle Commission.

Wide Expansion of Services

In the earliest period of their existence the Foreign Trade Zones provided only limited services, primarily the privilege of trans-shipment without Customs interference. It is interesting to see how these services have been expanded. For instance, in some cases regular Customs quotas on cargo, even though it is merely being trans-shipped, would not allow the commodity to enter the country, if there were no foreign trade zones.



Foreign Trade Zone No. 4, Los Angeles, stands at the entrance to the main channel.

A good example of lowering the cost through a trade zone facility can be found in the importing of mahogany. By drying the timber in the Zone before placing it on the market it is a better quality and the weight is cut down by as much as one half-pound per board foot and results in a major saving in freight costs. In the same way it has been found advantageous to import Brazil nuts through the Zones, where they are stored until dry. This again substantially assists in lowering freight costs.

As there is no restriction as to the length of time goods may be stored in the Zones, merchants are able to place their goods on the market at the times most advantageous to themselves, thereby avoiding loss through depreciation of prices. Alternatively, they can reship them to another country altogether if it is to their economic advantage, and in which case, no Customs duties have to be paid as, theoretically, the merchandise has not entered the United States.

Another useful facility is the freedom importers have to process, label and repack their goods after entry into the Zone. For example, unit lots of merchandise can be broken down to save in freight costs, and sheet aluminium, which is easier and cheaper to ship in its natural form, can be manufactured or fabricated in the Zone before sale.

Unrestricted public display of merchandise is an important facility afforded by the Zones. Buyers are able to thoroughly inspect and sample the goods before purchasing. In fact, traders can even sell their cargoes within the Zone, and in this case the dealers pay the import duties as they take the purchases into the country. San Francisco Foreign Trade Zone has gone one step further and now provides the facility of a Sub-Zone at the City's Annual Trade Fair, which, in March, 1956, will be further exploited with the opening of San Francisco's new World Trade Centre. No wire fence will surround the Sub-Zone display at the Centre but there will be a close watch kept by the Customs Service. Thus European and Far East exhibitors will be able to display their goods without paying duties. The Los Angeles Foreign Trade Zone is also considering the establishment of a Sub-Zone in the city itself where importers would be able to display their wares.

Not all the emphasis in the Zones is on import and re-export goods. Foreign flag steamship operators are finding the Zones useful for storing their ship supplies, out of which supplies may be drawn for use as needed without paying import duties.

Foreign Trade Zone No. 5, Port of Seattle. British made cars in storage.

Port Accounting

The Management of Financial Records

By THOS. HAWORTH, C.B.E., F.S.A.A.

Introduction

IN the United Kingdom, most Dock and Harbour undertakings are established or incorporated under special Acts of Parliament which usually prescribe the character of information to be given about finances and maybe, also, the form in which the annual accounting is to be set down.

It is not the purpose of this and the following article to spend much time on these aspects of dock and harbour accounting. In essentials they have been considered and discussed in the recent socialization of Transport. Most early examples followed the so-called " Double Account " system and while the principles upon which that system was based have not materially changed, there has been some latitude in the form of presentation.

For its own domestic purposes, every undertaking of more than primitive or modest dimensions, will find it necessary to supplement the information obtained in the compilation or preparation of the official accounts, with other information which may be more minute in its detail or more precise in its description or designation. Such an undertaking will want to know not only that its revenues are so much in total, but whether, for example, they are derived from shipping or from cargoes, or again maybe, whether derived from coastwise or foreign trading. In greater detail still it will desire to know how these revenues and/or their corresponding expenditures are to be associated with the various sections of the undertaking and the managers, superintendents or other officers under whose direction they are earned or incurred. And of course there are many other objects and purposes to be sought.

Particularly since the end of the war, there has been a large amount of attention given to the so-called " Management Accounting " as the modern development of the earlier " Cost Accounting " has come to be known. In the sense that the newer title appears of itself to cover a wider field than the earlier and perhaps more elemental " costing " was likely to convey, the newer title is better and more appropriate.

Whereas formerly there was a tendency to concentrate on the " end product " or service, admittedly with availability of detail, we are today, it seems to many accountants, much more interested in the dynamics, in terms of the personnel who keep the wheels going round and upon whose competence and efficiency the ultimate success or failure of the undertaking depends.

It happens to be the fact that the attention paid or given to Management Accounting has had reference to the manufacturing type of undertaking, but of course there is nothing restrictive about it.

The same broad principles and the same methods and procedures are equally applicable to undertakings offering a service as to undertakings selling a product.

It is proposed to examine Dock Accounting in this modern setting; not by any means as offering some ready-made system but as being something which can be adapted to provide the information which the management will either require or find useful in the control and direction of the undertaking.

Just as there can be many different types of undertaking manufacturing the same product, so there are dock undertakings with a wide diversity of interests. There are dock undertakings proper in the sense that they provide a berth for vessels in sheltered waters. There are independent Harbour and Conservancy bodies, though these duties and functions are sometimes found to be vested in the Dock undertaking. In some places the Port undertaking may control the Pilotage; in others it may be responsible for the lighting and buoying of the Harbour and its approaches.

There is also wide diversity in the handling of goods and cargoes. Here and there we find the Shipowner—or a stevedore acting on his behalf—undertaking the port transport work to the exclusion of the dock authority. He will have an appropriated berth or an agreement providing him with quay and shed space. Various services are supplied to him: the use of cranes and derricks; electric power and light, etc., but the dock authority will have nothing to do with the delivering or receiving of cargo.

In other ports we will find these operations undertaken by the port body itself, or maybe, partly so. For example in London, the shipowner will discharge and deliver the cargo in some docks while the Port Authority do the work in other docks. In London the Port Authority receive and lay out to port markings all export cargo, subsequently trucking to ship side when loading begins, whereas in Liverpool the export cargo is received and shedded and loaded by the Shipping Company.

There is also wide diversity of facilities and services and of plant and equipment. Dredging, Towing, Lighterage, Grain discharging, Dry docking to name but a few of the more important. There may also be Harbour Inspection craft and maybe riverside wharves and piers in the case of a Harbour or Conservancy body and probably also Wreck Raising and Wreck Marking craft and equipment.

It is to bodies of this diversity of services and operations that we have to devise and fit our Management Accounting. There can be no hard and fast rules; we shall have to be guided by the circumstances, looking all the time for the significant and realising that there is a limit to the dividends to be earned by paper work. Above all let us be clear that our purpose is to measure and record performance or achievement not only in monetary units but in other units as well. Indeed we want, where possible, to segregate or isolate input and output in terms or units which will give us an efficiency ratio for statistical comparison of progress.

This view of Management Accounting is really very important. One such ratio which comes immediately to mind is " cost per ton." If we are discharging a bulk cargo, say, of grain, using a modern grain elevator, our repeated operations for a succession of vessels are not likely to differ greatly and our cost per ton will not differ significantly.

But they are likely to differ from our costs when discharging a General Cargo ship and even among themselves General Cargo vessels may have more or less packaged cargo and differ one from another or in a succession of voyages.

In a small port with no great variety of shipping or of cargoes handled, cost per ton may be a useful indicator, but in a port of moderate dimensions, "cost per ton" will have to be qualified either by commodity or operation to be of much use.

At this stage it would be useful to ask and if possible to try to answer, a rather important if not indeed a fundamental question. As a rule we want information as a guide or a prompter to action; sometimes we want it for its interest as a piece of information, though we may be able to do nothing about it. But if we are wanting the information regularly and systematically and it is not possible to use it for purposes of control or direction, we ought to be satisfied that we are paying for a luxury we can afford. In my long and varied experience I have no hesitation in saying that there is far too much time taken and paper used in compiling information to the sole use and purpose of interest rather than for action. Or it may be that it is supplied for an immediate purpose and continued long after the purpose has been satisfied.

I am not of course saying that interest alone is not sufficient to justify some particular form of record or return. It may be information required by the Board or the Management which it would be unwise for the Accountant to argue about—to say the least of it. It may be information which, while having no current use or purpose, may yet become of statistical significance with a succession of measurements over a period of time.

Nevertheless it is a useful approach to look very critically at every piece of paper used in the procedure. The seemingly ingen-

Port Accounting—continued

uous question! What is the purpose of this record or return? is likely to evoke an astonishing variety of answers, which leads one to examine another aspect of this use of paper and the preparation or compilation of information for personal use rather than as being part of the official scheme of things.

There must be few undertakings where at some stage an officially required record is not kept in another form, quite unofficially, for personal reasons. It may be for self protection; it may be to have the information at hand so as to answer the question that never comes along; or it may be for just no reason at all.

These are matters which are not peculiar to accounting, but they have an important bearing on the success of any scheme of Management Accounting. They indicate the desirability, if not, indeed, the necessity of close consultation with all those who will be involved. If it is part of the official scheme of things that at some stage we shall be presenting an account of the stewardship of Mr. X as the person responsible for the operations, say, of a quay or wharf, we must take steps initially to see that he has confidence in our endeavours.

Of course the modern development in Management Accounting has emphasised the importance of using standards as part of our technique. At each point of operation where we intend to focus our measurements, we shall expect to have a series of standards. They may be standards in physical terms relating to technical efficiency and they may be standards of cost in monetary units. Our Mr. X will have been consulted about these standards, even if he has had no hand in their build up, and that consultation or collaboration should of itself earn a confidence and perhaps generate an enthusiasm for the accounting procedures which are to produce the story of a performance for comparison with the standard.

This business of budgetary control and the setting of standards has many interesting facets. It involves initially a fairly vigorous planning of our accounting procedures to establish the points at which we can set up standards. We are also likely to be concerned with the character of the standard itself. Is it to be a measure of expectation, or of hope, or of promise? Shall it be set on the low side in the hope of making a better showing, or shall it be set high in the knowledge that, even if it is not reached, it will have induced an effort?

It must be admitted that the opportunities for introducing a comprehensive scheme of budgetary control and standard costing are on the whole less likely in the dock and harbour industry than in many other industries. There are the vagaries of weather and of tide, and the seasons of the year also play their part, and these considerations particularly apply where the port undertaking employs large forces of port transport labour in the handling of cargoes.

Classification

Our efforts in accounting, in the hitherto usual way, have really amounted to an exercise in classification. We have classified our transactions as being on Capital Account or on Revenue Account and then by sub-classification, as between Income and Expenditure with certain conventional headings or descriptions.

In some undertakings we have gone further and established a sectional or departmental identity of our transactions and so have built up a series of departmental accounts; and it is in respect of this latter characteristic of identity that we are largely concerned in our Management Accounting. It has other features as well, but for the moment let us look at these more elemental and perhaps primitive considerations.

We have, as it were, a two-fold aspect of every transaction; we have (a) the type, as expressed by certain conventional headings, and (b) the accountability, as determined by the form of the organisation, primarily in terms of personnel, but also in terms of product, operation, process, service or type of plant.

Just as in our personal ledgers, we have long been in the way of using account numbers as a means of identification. We will use one series of numbers to indicate our type classification and the same series or an extended series to register the accountability. We will have a composite number, may be of five digits, the first two digits to indicate type and the following three digits to denote accountability. And if we decide that a number of five digits will be sufficient for our purpose, we will take care that we always use five digits and not cut the noughts when using units or tens, and that we always maintain the same order (a) : (b) or of course (b) : (a).

These features are best developed by what is sometimes known as a Plan of Accounts, of which the example subjoined can be adapted or developed to suit most types of undertaking. (See Fig. 1.)

Since transactions on Capital Account are likely to be much less frequent we may find it useful to adopt a three digit number for such items and to use only a two digit number for our Revenue items: apart from being distinctive in form it will have an economy of effort.

In this Plan we have set our permanent Capital Expenditure under nine groupings, the division which would be satisfactory for most undertakings. But we will no doubt desire some further subdivision: for example to group cranes of the same type or make or loading: to distinguish "A" class tugs from " B " class tugs and from Harbour Service Craft. We may want to distinguish Lifts and Elevators from Conveying plant or from mobile or portable units such as Electric trucks and other such mechanical handling plant and equipment. At least we will probably desire this amplification in an undertaking large enough to possess plant or machinery on the foregoing lines.

For these purposes we extend our Plan of Accounts by sub-classification as:

Cranes, Conveyors and other Plant. 105.	
3 ton Electric X Quay Cranes ...	105.01
5 ton ditto	105.02
Y type Electric Runabout trucks ...	105.11
Z type Fork Lift trucks	105.12
Floating Plant and Craft. 107.	
Class "A" Tugs	107.01
Class " B " Tugs	107.02
50 ton Dumb Barges	107.03
A type Pneumatic Grain Elevator ...	107.05
B type ditto	107.06
Dredger A	107.08
Dredger B	107.09

and so on as the circumstances or the conditions seem to require.

Possibly the most important reason for this means of identification is to follow up the expenditure on repair and maintenance. When we have several units of the same type we are not as a rule interested in the cost of each unit: a mean cost for the type is usually a better guide. And if it should happen that one unit turns out to be a " rogue " and quite unrepresentative of its type, that fact is usually well known much in advance of any accounting information or measurement.

Another reason or purpose is to associate the labour attending or operating plant with the type or unit on which the men may be engaged, because as well as using these sub-classification numbers for our initial expenditure on Capital Account we can, by suitable arrangement, use the same series or significant parts of the same series. Thus :

Attending and operating Fork Lift trucks	01.512
Repairing Class "A" Tug (own staff)	02.701
Ditto (Shipwrights)	13.701

Of course there is no end to this sort of thing and one must be guided by the size or the character of the undertaking. It may be useful to point out to those desiring further information in this field that there are descriptions of the Dewey Decimal Classification to be obtained from the Public Libraries or from some of the Professional Libraries. There are also many illustrations in professional literature, reports of lectures, etc.

Above all, one must preserve a sense of balance. It is no use creating classes or types of expenditure unless they are going to tell us something worth while which otherwise we would not know. A Dredger may be a big enough plant unit to be distinguished from other such plant whereas if we have only one or two Electric runabout or Fork Lift trucks, it will be of no consequence—or as

Port Accounting—*continued*

REVENUE ACCOUNTS									CAPITAL ACCOUNTS		
00 Port Transport Work	10 Carriage & Haulage	20 Process Materials	30 Rents, Rates & Taxes	80 Interest on Port Stock	90 Interest Received on Investments	100 Docks, Quays & Wharves	110 Work in Progress	120	170 Port Stock "A"	180	190
01 Operating & Attendant Machinery	11 Towage & Lighterage	21 Consumables	31 Legal Fees etc.	81 Other Interest	91 Other Interest Received	101 Roads, Fences & Boundaries	111 Stocks & Materials	121	171 Port Stock "B"	181	191
02 Repairing & Maintaining	12 Dredging & Removal	22 Fuel	32 Incidentals	82 Other Net Revenue Debits	92 Other Net Revenue Credits	102 Warehouses & Storage Buildings	112 Investments	122	172 Bills & Bonds	182	192
03 Administrative & Executive	13 Repair & Maintenance	23 Spare Parts	33	83	93	103 Power Stations & Workshops & Other Bldgs	113 Debtors	123	173 Capital Reserves	183	193
04 Supervisory & Clerical	14	24 Postages, Telephone etc.	34	84	94	104 Motive Power Plant	114 Cash at Bank	124	174 Revenue Reserves	184	194
05 National Insurance	15 Gas	25	35	85	95	105 Cranes, Conveyors & Other Plant	115 Cash in Hand	125	175 Sinking Funds	185	195
06 Pension Fund	16 Water	26 Printing & Stationery	36	86	96	106 Railways & Rolling Stock	116	126	176 Provision for Maintenance Renewals etc.	186	196
07	17 Electricity	27 Insurance Compensation & Claims	37	87	97	107 Floating Plant & Craft	117	127	177 Creditors	187	197
08	18	28 Advertising & Publicity	38	88	98	108 Piers Moorings & Breakwaters	118	128	178	188	198
09	19	29 Travelling & Car Expenses	39	89	99	109	119	129	179	189	199

Fig. 1. Plan of Accounts.

rule, of no consequence—if they are lumped together.

Furthermore, in designing our system of classification the means of analyses at our disposal must be borne in mind. It may well be that our methods of financial accounting and day to day records can be framed to produce much of the additional information with little more effort, but the cost of producing further information needs to be carefully weighed.

Again, our classification numbers or code numbers as they are often called, must in many cases be applied, in the first place by foremen and others of similar grading, who, although skilled practical men, have little interest or aptitude for clerical and accounting processes. The more complicated the system, the greater is the likelihood of error of a nature which may be undetected for a long time.

So far we have been concerned with the type or class of Expenditure and in laying out a scheme of numbering to ease our labours. Of much more importance in Management Accounting is the accountability of the expenditure, for here we are looking, as it were, at the departmental aspect. We have to divide our undertaking into so many sections according to our activities. In Dock and Harbour working we will have, for example, the Harbour Services, which may cover such duties as Inspection of Craft and Regulation of Movement and Mooring. In a large harbour these services may be divided into districts. Akin thereto and appropriately coming under the control of the Chief Harbour Master, we may have another section engaged on Wreck Raising, possibly allied with the laying down and inspection of Moorings.

As part of the Harbour accounting therefore we may have two or three more sections initially under the control and direction of the Chief Harbour Master, and the question arises as to whether we shall treat the whole of these activities as one accounting unit, or whether we should make some subdivision.

So far as the ordinary Harbour Service duties go, there is probably no case to be made, if, as is thought, most of the personnel are established staff, and the expenditure is likely to be approaching a constant. Nor is there likely to be any case on the revenue side, since Tonnage Dues will not vary so much with the place where a vessel is destined as with the character of the vessel or the usual distinction between Home Trade and Foreign.

But it would be desirable, to say the least, to have a separate accounting for the Wreck Raising operations, since these are usually carried out on a recoverable basis and it may otherwise be difficult to establish a suitable loading for supervision and overhead or to furnish satisfactory evidence in proof, when the charges come under the scrutiny of the Insurance Assessors. Even if an internal Insurance Fund is in operation, some such accounting is desirable if the fund is to run on sound and economic lines.

We are faced with much the same sort of problem when we look at the operations or activities of the Quays and Jetties, though here again there can be no hard and fast rule. Here our Revenues consist usually of two classes of income: that derived from the Shipowner for services or facilities rendered to the vessel; and that derived from the Merchant or Trader for services in the handling of goods and cargo.

This distinction between goods and shipping in their contributions to the upkeep and functioning of the Port or the Dock is a matter of some importance. On occasion it has been claimed by Shipowning interests that they have been paying an undue share of the overhead or Central Charges of this or that Dock or Harbour. It may be that for the Harbour or Conservancy services a separate accounting is prescribed by legislation, though here the conflict between shipping and goods is hardly likely to be serious.

Just what are the arrangements for the billing and collection of revenues does not matter a great deal. But it is important that, in so far as they are segregated between shipping and goods, so too must we segregate our expenditures. We want to bring together input and output in monetary units to see whether our charges are justified and equitable.

So we will have the Dockmasters Dept. as an accounting unit and we will have one or more Transit Officers, Warehousekeepers or Wharfingers who will be in charge of the Quayside operations, as other accounting units. Indeed we will have in general units or sections: (a) in contact with and giving a service to the public as a means of earning revenue, and (b) general service units or sections which offer no service direct to the public.

Yet again we may have what could be called "Pseudo Service" units which are nothing more than an accounting convenience or device. In a large undertaking we may have several blocks of warehouses, some of two or more storeys. They will be used for housing quite different cargoes or commodities and very probably they will be under the supervision and control of several Warehousekeepers. It matters little in the long run where goods are stored; there will be the same charge for like commodities whether stored at "A" or stored at "B." Some will be modern and others

Port Accounting—continued

will be older, if not differing greatly in type of construction.

As a matter of organisation, the Chief Engineer will probably be responsible for seeing that accommodation is provided and maintained, together with the usual public services of water and light. So we could have a pseudo service accounting unit—"Housing Service," if you like—in order to collect all such charges as Repair and Maintenance, Water, Lighting, Heating etc. into an overall rate per super ft. available for occupation. At a later stage in our accounting operations we shall want to see how our various warehouses and their warehousekeepers are making ends meet and we shall be saved much effort and difficulty in arbitrary allocation if we can establish a charge or debit for the occupation of X sq. ft. of warehousing space at Y shillings per foot. And if someone, in a desire to be critical, feels that cubic capacity is a truer measure of warehousing space, I would not be disposed to contest cubic feet as a more suitable element of charge in certain circumstances. Incidentally, the fact that such information is at hand will be a strong point when representations are received asking for a reduction of charges.

We have discussed Housing Accommodation and its charges at some length, not so much for its importance as for the illustration it has afforded. There can be and will be other services of much the same kind to be dealt with in much the same way. Electric Power would be another example. Power is usually bought at High Tension bulk rates, but it has to be converted or transformed to working voltages and of course distributed to the various consuming units of plant: cranes, lifts, pumps, motors etc., so we want to get an all in cost per unit at the point of consumption which will either be separately metered or assessed on time rating constants or other appropriate basis.

Yet another example which may usefully be considered would be the supply and servicing of Electric Runabout trucks held at some central gear stores for use by departments at call. We would have an all in charge to cover battery charging and maintenance as well as other incidental charges, to be recovered at X shillings per hour, for time absent from depot, as a suitable unit for measuring the value given by the service.

A little earlier we have spoken of charging at the point of consumption: it has alternatively been spoken of as "charging at the point of the tool," particularly in reference to Machine Shop practice. What in fact we are doing is to identify or to isolate the "end product" of the service in a form which can be counted or measured. In a Dock of any size we may have an internal rail haulage service. Where distance from point to point is likely to be a small factor of the total cost of moving goods from place to place, for all ordinary purposes, a simple cost per ton moved is to be preferred, against any more exact accounting based on ton-miles—and for very obvious reasons.

Presentation of Results

We have been discussing so far some of the considerations which will have to be looked at when planning a Management Accounting Scheme and organisation for a Dock and Harbour undertaking. And it is now time to think about drawing together the loose ends of the discussion into concrete and practicable form.

Apart from special reports covering sections of our activities and operations, we are visualising some form of intermediate account bringing together all activities. Such an account is often referred to as an Operating Statement, to be made up each four weekly period or with the 4-4-5 week sequence to fit in with the quarter year. (See Fig. 2.)

The degree of accountability to be covered by such a statement when compiled at monthly or four weekly intervals, is, I think open to argument. In manufacturing industry, service charges such as we have been discussing earlier, are often taken to account and so too are charges for maintenance and perhaps also capital or debt service charges. We may even go the length of allocating or apportioning central charges for administration on some basis of equity or logic.

OPERATING STATEMENT FOR THE _____ ENDED _____

Dept. No.	Dept.	PAY ROLL £	CONTRACT SERVICES £	PUBLIC SUPPLY SERVICES £	MATERIALS £	OTHER CURRENT EXPENSE £	ANNUAL EXPENSE £	DEBT SERVICE £	£	INTERNAL SERVICE TRANSFERS £	TOTAL DEBITS £	BILLS RENDERED £	INTERNAL SERVICE TRANSFERS £	£	TOTAL CREDITS £	BALANCE £
	ADMINISTRATION															
01																
02																
	REVENUE EARNING															
10	Harbour Master															
11	Dock Master															
12	Transit Officer															
	SERVICES															
20	Electric															
21	Hydraulic															
	etc															
	PSEUDO SERVICES															
22	Housing															

Fig. 2. A typical Operating Statement.

On the other hand it could be argued that such a complete monthly accounting is more than is likely to be warranted for the operations of a Dock and Harbour undertaking. This would particularly be so where the undertaking was providing facilities rather than engaging in industrial operations. And even if labour services are provided for the handling of goods and cargoes, it does not appear that a complete accounting to include the Services and Central Charges would be worth while at more than quarterly intervals. Indeed, on the footing that information about the current charges is made available, either week by week or month by month, a yearly summary is likely to meet most requirements.

In this connection it is useful to recall the views of the British Transport Commission about the allocation of Central Charges. Notwithstanding the reasons which have been given in the Annual Reports—especially in the First Annual Report on the accounting basis and principles, it is, on the much smaller scale of the Dock and Harbour Authority, most desirable, if not vitally necessary, to have some knowledge of the dead weight charges for debt service and for the central administration.

The original set up of the Transport Commission was for the integration of all activities into the one financial structure, which should be able to pay its way taken altogether and taking one year with another. It was indeed taken for granted that on a strict and separate accounting, rail transport would not initially be able to make ends meet, whereas road transport could be expected to provide a surplus. And in the views of the powers that be, it was fit and proper for any such surplus to be applied, in essence, as a subsidy to the non-profitable rail transport undertaking.

Port Accounting—continued

There is another aspect of this financial set up which comes much nearer home to Dock and Harbour circles. For many years before the war, the "Trust" ports had complained of unfair competition from the Railway ports. It was averred that the Railway ports were looked upon primarily as feeders of rail traffic and were being subsidised to this end out of the railway revenues. The complaint could not be established absolutely in the absence of a separate and complete account, but there was little room left for disagreement.

The accounts of the Transport Commission are better both in their form and in their matter. They still avoid the allocation of the Central Charges on principle, but leave it to anyone to devise and apply some formula for making an allocation, which, by reason of the predominance of the charge for interest, now leaves little room for disagreement or difference of opinion.

This digression has tended to interrupt the description of the Operating Statement, though to some extent it has exemplified its purpose or at least one of its purposes. It would be desirable therefore, at this stage, to take a look at such a Statement, rather for illustration than as a specimen to be followed. Conveniently it could be a tabulation of expenditures with cross footings by departments: or the other way round if the departments are few in number. It purports to pick up all ordinary items of expenditure and revenue and to set them, suitably aggregated, of course, according to their departmental or service accountability as a first stage. It also aims to bring to account against the revenue earning departments the transfer for the service benefits such as electricity, hydraulic power and as earlier indicated such pseudo service benefits as Housing accommodation, of course where applicable. Lastly also to set revenue against expenditure and to detail a series of balances which should, in total, accord with the ordinary operations of the undertaking for the period chosen. It would ordinarily omit Income Tax and extraordinary items of the character of appropriations which bore no relevance to the working of the undertaking for the period under review.

Such a statement could be amplified with information about output—using the word in its widest sense—for example, the number and N.R.T. of shipping; the tonnage of cargo handled; the units of electric current bought and distributed; the available warehousing space; the capacity occupied and the cost per unit (sq. foot or cub. foot) and this, as well as the financial information, could be compared with the like information of the previous period.

It will have been seen, from a study of this specimen Operating Statement, that by its vertical totals it follows the character of the usual Revenue account in which the account names would conform in detail with those suggested in the Plan of Accounts, which are here grouped for economy and convenience. There is nothing final or absolute in all this: the classification is conventional, but it is certainly desirable that it should conform with the official or statutory account to simplify reconciliation and to establish that it is a true accounting document.

However it is in its other features that this Statement becomes important, for here can be seen the results of the various activities, suitably detailed to the size and character of the undertaking and grouped or allied with the various officers, managers or superintendents in charge of the different activities.

At an earlier stage it was suggested that care should be taken to keep the subdivision of operating activities within practicable limits. A large undertaking might find that some hundreds would not be too much, whereas for a small undertaking which only provided facilities and left cargo handling to the shipowner or trader, only the simplest subdivision would be worth while.

It was also suggested that our accounting should provide information to establish the fairness of the charges as between the various interests using the port or harbour. In fact most ports and harbours have charges, some of which are subject to statutory limitation, while others are entirely at the discretion or determination of the harbour authority. From what has been said, it should be left in no doubt that, whatever else is done or contemplated to be done, accounts should be available to establish the equity of the charges and the case for any increase when permission to that end comes to be sought.

This Operating Statement, or account, by whatever name it may be called, will be found to be one of the important instruments of control in most undertakings, though in precise form it may differ. In a manufacturing industry we are usually able to count or measure output in some acceptable stable unit: it may be in weight or in packages or yet again in volume and ordinarily it can be expected to be a function of the input. For example: the more the labour engaged, the greater the return.

In the dock and harbour industry we have a different state of affairs. The number and the tonnage of vessels handled during a day, a week or a month is dependent upon many factors, such as weather and tide and maybe, the seasons of the year. Our dock entrances are, probably, manned either round the clock or on a tidal rota as determined by long term survey, and we cannot relate output to input except on a long term basis.

Or again, if we are engaged in cargo handling, we may find it rather a problem to get a satisfactory measure of the work done. We may have the weight in total of a mixed cargo, but there are a variety of operations to be undertaken: some for immediate delivery: some for warehousing and some maybe for delivery overside. And of course there can be wide diversity of cargo, and in its packaging. Taken over the year and taking one year with another, tonnage of shipping and tonnage of goods will usually be a very good measure of progress, but in short term, over a week or a month, and particularly for mixed cargoes, tonnage should be read with caution.

It is, or it should be, a common place in Management Accounting for information to be presented in a form suiting the status of the officer or person who will be wanting to use it. In that way we have been looking at the Operating Statement as a document for the use of the General Manager or other similarly placed officer regardless of official designation. It would not ordinarily be an account or document for the Board or governing body, though it would be the background for many reports to that body.

Statistics

There are, of course, many other sorts of report or account giving a current picture, in considerable detail, of the several branches of activity. For example, the departmental or divisional managers are likely to want information about their weekly pay roll; of hours worked and output, insofar as it can be counted or measured, and of other data in natural as well as in financial terms and units. A review of some such activities and the kind or the sort of information which could be useful, should provide a good supplement to the operating statement.

It would be well for a moment to have a word about statistics and their relation to accounts, since many people are in the way of accepting that statistics are concerned only with non-financial matter. Of course that is not so; it is not the unit that determines the distinction but the period of time to which the data relates.

Very generally it can be said that information which is current and relates to one period of time, whatever the units employed, is an account, whereas a succession of information or the same sort of information covering a succession of like periods is statistical. We look upon accounts as being "live" matter about which we may be able to do something in the short term, whereas statistics are, as it were, so much "dead" matter, which are more likely to be of use in the long term in the determination of policy. Thus a succession of information taken from accounts in financial units, year by year, or period by period, must properly be looked on as statistics.

This review of the association or the relationship of accounts with statistics is prompted by the attitude which operating and technical staff are sometimes minded to adopt about the counting, measuring and recording of non-financial data. It is not to be denied that in the conduct of operations, there will be information of a peculiarly domestic character with which the accounting organisation is not likely to be concerned. That is not because it is statistical in character, but because its interest and usefulness is purely local, and its impact on the undertaking comes to be measured in some other way.

(*continued at foot of Page* 336)

New Timber Storage Building

Designed by Timber Development Association

There are many problems involved in the design of storage buildings, problems such as final cost, appearance and whether the building properly carries out its job. These may not be apparent in a completed building particularly if it is a successful one. To satisfy these requirements using timber as the structural material involves the use of an age old building material in terms of modern spatial planning, the main points being the use of improved structural techniques and a fuller appreciation of efficient design in timber.

In most cases the first approach to the design of an industrial or storage building appears to be the desire to obtain the largest possible uninterrupted floor area to provide freedom of movement within the structure. This approach may unintentionally lead to an expensive building, and it might be wiser to endeavour to relate the functional requirements to an efficient use of the structural material.

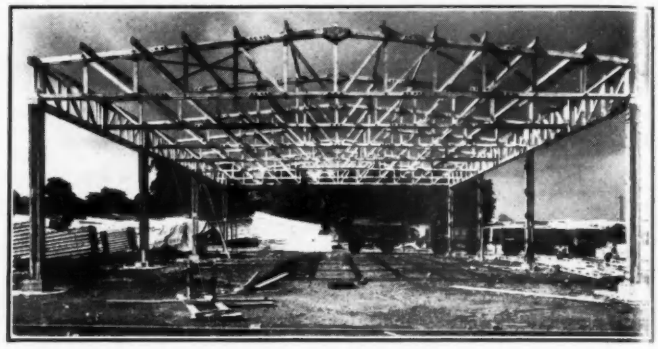
The first consideration is the planning grid; this should be determined by the functional requirements and not by the size of any prefabricated unit. It is some arbitrary system of centre lines which will determine the column layout. This spacing, or rather the minimum spacing requirements, are determined by the storage required, width of traffic lanes, and the type of handling equipment to be employed. Due reference must also be made to the limiting member of the structural system and an economical maximum span for trusses.

A further consideration and one which will determine the visual success of the structure is its completed appearance. Its mass and scale must be satisfying, and the results of efficient planning, structural design and the correct application of known functional requirements will achieve this end.

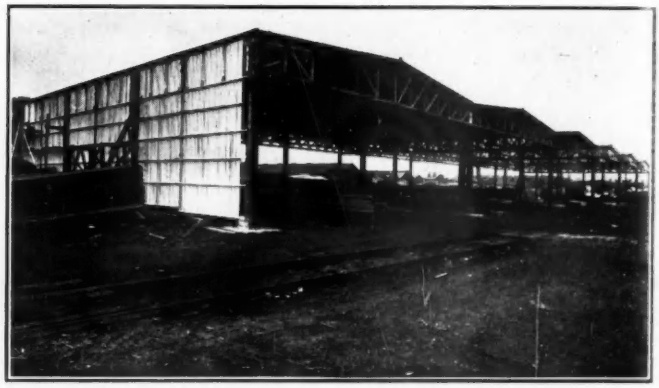
With the new timber storage building at Falkirk an opportunity arose to put into practice some of the above principles.

It was necessary to provide about 26,000 sq. ft. of covered storage in an existing yard which had a slope of 1 in 70 from south to north and contained existing rail sidings at 120 ft. 0 in. centres. It was, therefore, desirable to site the structure between the tracks and in such a position as to facilitate unloading by hand or by mechanical means. To allow sufficient clearance, gangways across the building were made 15 ft. 0 in. wide, and 20 ft. 0 in. was allowed for the stacking depth.

Consideration was given at this stage to the type of roof structure related to economical maximum spans for timber, together with the satisfactory massing of completed elements. It was decided to adopt a Pratt girder with a 4° slope to the top chord which has economical limits of 50 ft. to 70 ft. spans with a spacing of 12 ft. to 20 ft.



One 54-ft. Span Bay



Boarding and roofing in progress

The planning grid then had to be decided, and the limiting use of solid purlins helped as regards truss spacing; thus a square grid 13 ft. 6 in. x 13 ft. 6 in. was arrived at. This gave a truss of 54 ft. 0 in. span, six of which formed the length of the building of 324 ft. 0 in. and six bays each of 13 ft. 6 in. gave a width of 81 ft. The columns are spaced at 27 ft. 0 in. centres, the intermediate truss being carried by a secondary girder at eaves level and within the depth of the main trusses at that point. There are five main valley gutters having outlets at the columns.

A minimum clear height of 16 ft. 0 in. was decided on, this being sufficient for the stacks and the operation of mechanical handling equipment. Due to the ground slope this would be increased to 20 ft. 0 in. at the north end, the columns being designed for the greater length and varied to suit the fall. The columns are set on concrete bases and located only by $\frac{7}{8}$ in. holding down bolts. The main girders are 54 ft. 0 in. span 5 ft. 6 in. deep at the centre and 3 ft. 0 in. deep at the bearing or eaves. The upper chords are formed of two 2 ft. x 6 ft. members and the lower chord of two 2 in. x 5 in. members. The intermediate struts are of 2 in. x 4 in. and 2 in. x 5 in. single members. Split ring connectors $2\frac{1}{2}$ in. dia. are used throughout. Purlins are 2 in. x 7 in. and spaced at 4 ft. 6 in. centres. The secondary girders are flat, 27 ft. 0 in. long, and 3 ft. $5\frac{7}{8}$ in. deep, consisting of two 3 in. x 7 in. upper and lower chords. The main trusses are carried on the lower chord at both the centre point and over the columns. Intermediate struts are single 2 in. x 6 in. These girders are rigidly connected to the columns by $\frac{3}{8}$ in. mild steel plates thus effecting transverse stiffness, whilst the connection of the trusses to the girders affords great stiffness in the alternate direction.

The whole structure was designed in accordance with the Code of Practice CP.112, 1952, and the timber used was Douglas Fir.

The roof finish is of asbestos sheets discharging into valley gutters which run along the upper chords of the secondary girders.

The building was completed in under three months by the owners, Messrs. Robert Melville and Co., Ltd., the design was by the T.D.A. and the whole scheme can be considered a fair and economical solution to the particular problem with an effective finished appearance.

Port Accounting—continued

As a general rule operating staffs are not the best people for laying out the most suitable form of record, and even for their own admitted domestic information the Accountant can often give help and advice. The character of the organisation will determine the relationship between the Accountant and the operating officers and particularly how far the so-called functional control of staff is to be followed or permitted. How be it, there is bound to be plenty of opportunity for collaboration and of course for agreeing on the work and the records which will be available for examination for the Internal Audit Staff.

One cannot lay down general rules. Geography is often an important if not indeed a deciding factor. In a large undertaking with operations dispersed over a large area, local staffs are probably best left to undivided local control, regardless of the duties on which they are engaged, whereas in a smaller unit, concentrated in the one spot, there could be something to be said for a more complete functional control.

(To be continued)

The Use and Misuse of Hydraulic Models

By RALPH W. POWELL
Professor of Engineering Mechanics at The Ohio State University, Columbus, Ohio, U.S.A.*

History.

ESTIMATES of ship resistance by towing small models are said to have been made in England as early as 1750, and about 1850, James B. Francis constructed at Lowell, Massachusetts, U.S.A., a 1 : 5 model of an inward flow turbine; but the first river model seems to have been constructed in 1875 by L. Fargue. The city of Bordeaux wished to improve the navigation channel of the Garonne, and there was a dispute as to whether dredging alone would effect a permanent solution. Fargue convinced the authorities that it would not, by building a 1 : 100 scale model of the river with a layer of sand about a foot deep in the bottom and passing a flow of about 7 cusec. through it. But if the model gave a true representation of the prototype, it was only by accident, for the horizontal scale was not the same as the vertical, and the diameter of the sand in the model was much more than one hundredth of that in the prototype.

The first man with a quantitative understanding of hydraulic similitude seems to have been Osborne Reynolds. In 1875 he reported tests on small models of screw propelled steamships and advised the Admiralty to construct models of proposed ships at a scale that would make it possible to install engines and test them as small launches. In 1886 he urged tests on "self-righting" life boats by means of small models, pointing out that opportunities to test the full sized boats in extreme storms were very rare, but that "the behaviour of a model 3-ft. long in waves 2-ft. high, and with a wind twenty miles an hour, would correspond with that of a boat 27-ft. long, in waves 18-ft. high, and a velocity of the wind of 60 miles an hour." Thus early he had realised one of the great advantages of model tests.

Beginning in 1885 he began a study of improvements in the estuary of the Mersey with a small model with sand bottom. A pan placed in the water was alternately depressed and raised to simulate the tides, and he showed that the only period which would imitate the motions of the actual tides in the estuary was 40 seconds, a result which he says might have been foreseen, "since the scale of velocities varies as the square roots of scale of wave heights—and the ratios of the periods would be the ratio of horizontal scales divided by the ratio of velocities." These experiments were continued by L. F. Vernon-Harcourt, who also made a model study of the improvement of the mouth of the Seine. These later experiments were continued by the French government from 1890 to 1895. Apparently the difficulties of experiments with movable bed models proved too great, for nothing more seems to have been done in France or England along this line for many years.

In 1898 Hubert Engles opened the first permanent river hydraulics laboratory at the Technical University of Dresden. The great development which followed, not only in Germany, but in neighbouring countries, and finally in all parts of the world, will not be detailed here. Suffice it to say that to-day hardly any hydraulic structure of importance is constructed without being tested, in whole or in part, by small scale models. The same is in general true of river and harbour improvements.

A very cursory scanning of "Recherches Hydrauliques" and "Hydraulic Research in the United States" indicates that in 1953-54 the number of hydraulic model studies in progress in the following countries was approximately:

Australia	16	Indonesia	3	Switzerland	19
Austria	14	Israel	4	Tunisia	3
Belgium	9	Italy	25	U.S.A.	196
Canada	16	Japan	18	Yugoslavia	33
Ceylon	6	Netherlands	20		
Czechoslovakia	9	Pakistan	13		
Finland	15	Portugal	4		
France	82	Sweden	17		
Germany	56				
Great Britain	23				
Hungary	12				
India	61				

This makes a total of 674. Unfortunately the figures are not available for Russia and a few other countries.

Theoretical Basis.

The mathematical basis on which models are designed, and by which the results obtained from the model are converted into corresponding values for the prototype are available in numerous publications and will not be repeated here. If gravity were the only force involved, a true scale model would automatically give dynamic similarity, that is, the Froude number of the model would be the same as the Froude number of the prototype, or in simpler words the velocity heads at all points would be to scale and the velocity ratio would be the square root of the length ratio and the discharge ratio would be the length ratio to the 2.5th power.

But there are always other forces involved, of which the most important is usually viscosity. It is generally stated that when viscous forces are involved, the Reynolds number of the model must equal the Reynolds number of the prototype. Fortunately this is not really true, for to make both the Froude number and the Reynolds number the same in the model as in the prototype would require a viscosity ratio equal to the three halves power of the length ratio. That is, for a 1 : 25 scale model the liquid in the model would have to have a kinematic viscosity only 1/125 that in the prototype. There is no liquid anywhere near fluid enough to represent water in the prototype if this requirement had to be met. Actually we find that for all kinds of flow, whether through pipes or in open channels, or through orifices or over weirs, if the Reynolds number is large enough, its precise value is no longer important. The above statement assumes that the pipes or channels have an appreciable roughness. There seems to be no practical way to make a small scale model to reproduce accurately the flow in a prototype so smooth that it gives smooth pipe or smooth channel flow.

It is often said that a model must not be too small or the Reynolds number will be so low that the flow will be non-turbulent, which could not correctly represent turbulent flow in the prototype. This is true, but the above example shows that the requirement is much more strict, that not only must the Reynolds number be large enough to insure turbulent flow; it must be large enough to insure rough channel (or pipe) flow. The Prussian Research Institute for hydraulics, Marine Design and Earth Testing, long ago set the lower limit of the Reynolds number in the model (as we are defining it) at 24,000. As seen by the example we have just worked out, this is a satisfactory rule if the relative roughness is 0.005, but is over safe if it is rougher, and not high enough if it is smoother.

Distorted Models.

Most river models are distorted, that is the horizontal scale is smaller than the vertical. This results in a great saving of space and cost for the same vertical scale, and also allows a smaller vertical scale to be used than if the model were undistorted. This may be seen from several view points. Since the hydraulic radius approximates the mean depth, it is considered a vertical distance and the ratio of $R_m : R_p$ equals the depth ratio D_r. But the slope ratio $S_m \cdot S_p = D_r : L_r$. Therefore to preserve dynamic similarity $C_m\sqrt{S_m}$ must equal $C_p\sqrt{S_p}$ and the model must have a smaller C than the prototype, that is, it must be relatively rougher. Or more simply, distortion increases the slope of the model, therefore it needs to be relatively rougher to hold the velocity to its proper value.

Movable Bed Models.

As noted above, the use of movable bed models dates back to 1875, but they have always presented difficulties. The earlier attempts to develop a rational theory were based on du Boys' formula that the tractive force per unit area $\tau_o = wSD$, where w is the weight of the following liquid per unit volume, D is the depth of flow, and S the slope. The fact that this seems to make the tractive force independent of the velocity has led many to be

*Abstracted from a more comprehensive article published in the "Port Engineer," July 1955, Calcutta, whose copyright is hereby acknowledged.

The Use and Misuse of Hydraulic Models—continued

sceptical of the law, but apparently the fact that at the same depth, different velocities require different slopes, takes care of the difficulty for a channel of uniform depth. The question remains as to whether in a natural stream or its model where the depth varies across the cross-section, the tractive force per unit area (that is the shearing stress at the boundary) varies directly with the depth at that point, irrespective of the local velocity gradient. The competing conception, that bed movement occurs at a certain critical velocity, is a case where "common sense" leads us astray, because the velocity at the very boundary is always zero, and the shearing stress depends on the rate of change of velocity in a direction, perpendicular to the boundary, and not on the velocity at any particular distance from the boundary.

In a method used in designing movable bed models two decades ago, some particular degree of movement (generally small) was selected as a standard, and the tractive force per unit area necessary to cause it was called the critical tractive force. A sample of the bed load in the prototype was tested in a tilting flume to find its critical tractive force (per unit area), and from it the necessary depth in the prototype computed. Similarly the critical tractive force for the bed load to be used in the model was determined, and the scale ratio of depths having been decided on, the slope to be used in the model could be computed. Since it is not practical to reduce size of the model bed load very much, lighter materials such as powdered coal, haydite, rosin, or plastic pellets are generally used. Experience showed that a combination of moderate depth distortion, moderate slope distortion (over and above that resulting from the depth distortion) and light-weight bed material, was better than the use of any one distortion alone.

However, this method has not proved very satisfactory and it has been stated that no help can be had from theory and that it is purely a cut-and-try process to build a model that will satisfactorily reproduce known changes in definite times, so that a time scale can be determined. When it has thus been verified the model can be used to forecast the results of proposed modifications in the river channel.

Einstein and Chien on the other hand, in a paper just published, present a very elaborate theory which the writer does not claim to have absorbed. They have developed a formula in which D is the effective diameter of the bed load particles and m and C are constants which must be determined experimentally for both the prototype and model separately. Seven distortions which may occur in this sort of model have been listed. As to whether these elaborate methods form a satisfactory theory on which to base the design and use of movable bed models must await further study and experiment. But the writer has always felt that some day a satisfactory theory would be developed, and Dr. Einstein and Mr. Chien are to be congratulated on their attempt.

Conclusion.

The use of hydraulic models is obvious from what has been said. The vast amount of time and money which continues to be spent on them testifies that they are worthwhile. It is probably safe to say that the total savings resulting from their use has been many times their total cost. In any particular case we cannot be sure that the model study will result in a saving in construction cost equal to the cost of the study. but even if no saving results, the the study is often worthwhile simply as a safeguard against possible errors in the design.

What of the misuse of models? It seems to the writer that these may lie in two directions. One would be needless testing. Money should not be spent to prove hydraulic facts that are already well established, or to check the operation of structures which are so similar to other structures that have already been built and tested that the results of the model studies should be evident without making them.

Another and perhaps more serious misuse of hydraulic models is to misinterpret the results they give. Even geometrically undistorted models may involve hidden distortions due to viscosity, surface tension, and the like. The necessity of keeping the scale of undistorted models large enough to minimise viscosity effects has been discussed above. Cavitation problems are not correctly represented by a small scale model unless an artificial atmospheric pressure is provided. As is obvious from what has been said above, the subject of movable bed models is still in an unsatisfactory state. There is the possibility that the results obtained are qualitative rather than quantitative or in some cases perhaps not even that.

To sum up, the hydraulic model is an extremely valuable tool, but one liable to mislead if used by one who does not understand its limitations.

Removal of Oil from Dock Waters

Successful Development of Oil Skimmer

Oil floating on dock water is a source of trouble and expense to dock authorities. Various methods have been tried for removing it cheaply and quickly but none has so far been regarded generally as successful.

Chemical means have been used to cause the oil to sink but the expense is too high to be justified in normal conditions. Sand in which the grains are coated with finely divided carbon has been used to absorb the oil and sink it. Again, the expense is heavy, the process is slow and there is some doubt about the permanence of the cure.

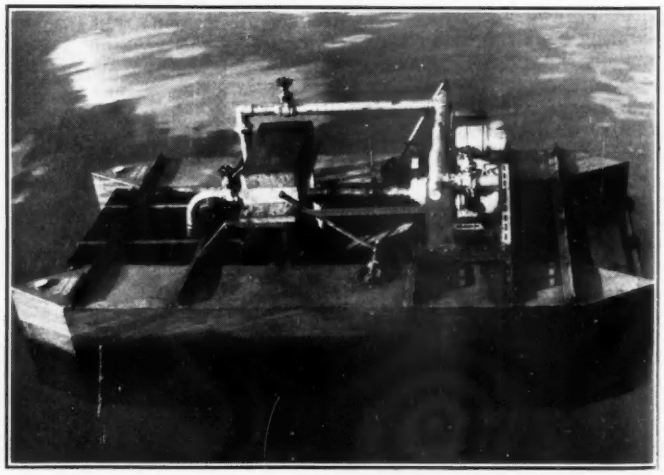
Experiments have been made with a mechanical device consisting of a floating tray forming a weir surrounding a sump. The buoyancy of the tray is so arranged that the weir crest is just below the water surface and a pump on an adjacent barge pumps oil and water from the sump to a container on the barge. The disadvantage of this method is that it is inherently unstable. If the pump gains on the flow of oil and water over the weir the tray becomes lighter and the weir crest comes nearer to the surface thus causing the pump to gain on the inflow still more. The converse is also liable to occur.

In an alternative device the tray does not float but is suspended from a gantry on a barge. Here again difficulties are likely to occur in maintaining the weir crest level with the necessary precision. A few other machines have been described but it is not known that any of them have been successful in continuously skimming the oil from the surface of the water without frequent adjustment of weir level by an operator.

In cases where the oil collects naturally, or may be driven, always into the same part of a dock, a fixed installation may be established to withdraw the oil over a fixed weir. The difficulty has been to make a similar arrangement work effectively afloat and mobile.

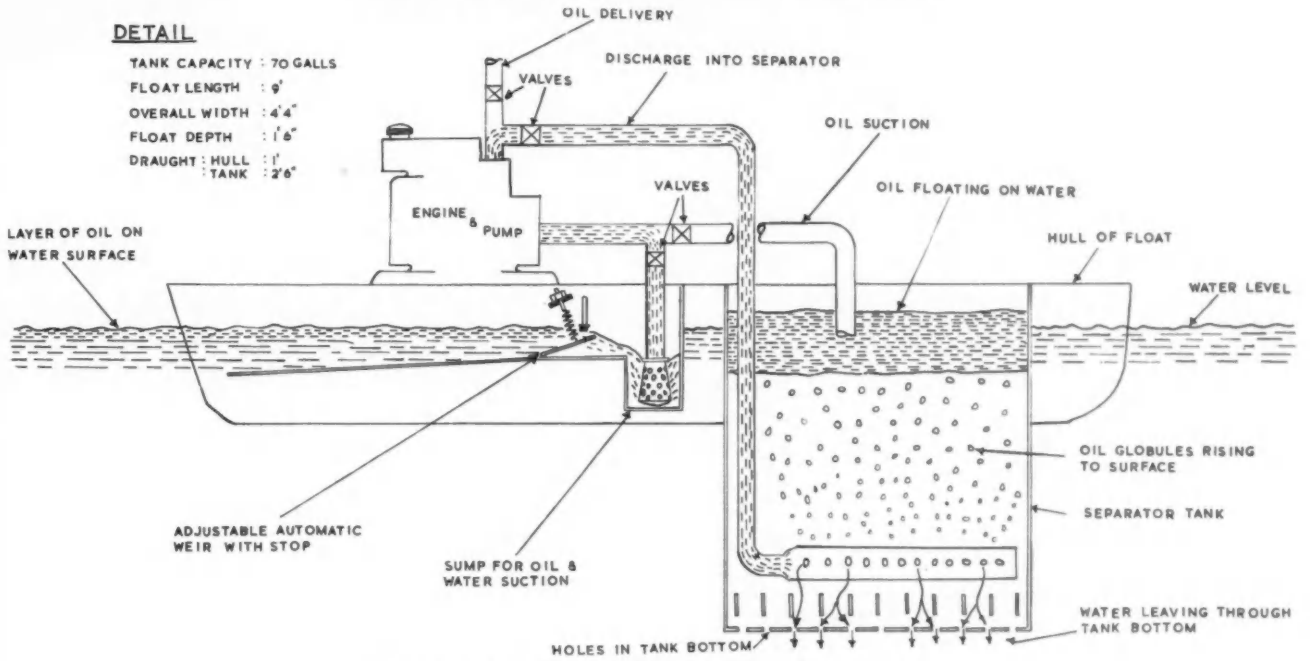
Present Investigations

In view of the lack of a suitable machine for this purpose the Research Officer, Docks and Waterways, of the British Transport Commission, undertook in December, 1953, to look into the



Side view of Skimmer.

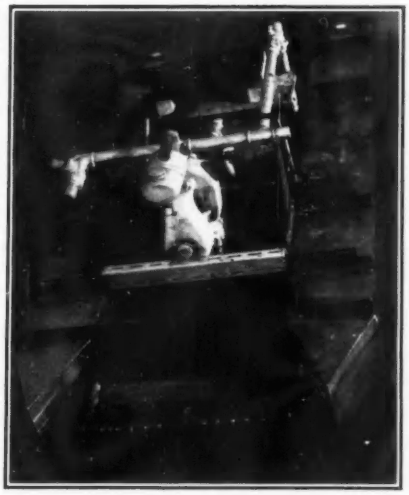
Removal of Oil from Dock Waters—continued



Prototype Floating Oil Skimmer and Separator (not to scale).

question and if possible put forward proposals for a satisfactory method.

Accordingly, a series of model experiments on oil skimmers was carried out at the Docks and Waterways Research Station during 1954. In the course of these experiments it became clear that any successful machine should embody the following features if it was to do its work afloat on the water:



Front view of Skimmer

(1) The machine should consist essentially of a weir and a sump. The weir shoud be situated near the centre of buoyancy of the machine so that any variation in trim should have the minimum effect on the depth of the weir crest below the water surface.

(2) The volume enclosed on the sump side of the weir, including the sump itself, should be small in relation to the total displacement of the machine so that variations in the water content of the sump should make little alteration to the weir crest level.

(3) From the sump the oil should be pumped, with a minimum of the underlying water, to a receiving tank with perforated bottom and suitable baffles so that the oil may rise to the surface and the water discharge below, thus crudely separating the oil from the water.

(4) The weir crest level should be automatically maintained at a suitable depth below the water surface to permit the passage of the oil film with the minimum amount of water. Variations in trim of the plant; in the thickness of the oil film; in the viscosity of the oil and its readiness to flow over the water surface; the amount of debris penetrating through the screen; the height of water in the sump (which affects the facility with which the oil is sucked by the pump) all need for their correction slight alterations of the weir level and these should be made automatically.

(5) An over-riding manual control should be available to the operator to control the limits of the automatic motion of the weir crest to take account of large variations in trim or buoyancy.

Prototype Machine

In accordance with these experimental findings a small operational machine was designed and built at the Research Station. It consisted of two pontoons held abreast a few feet apart. The pontoons were of large enough displacement to carry not only themselves but also the weir, the sump, the pump, a receiving tank and the operator. The weir was made a few inches from the centre of buoyancy. The volume enclosed behind the weir, including the sump, was reduced to about one fourteenth of the displacement of the machine. The weir crest level was automatically controlled and also adjustable by the operator if required.

The automatic control of crest level was made by hinging the weir forward as shown in the drawing. The weir was supported by a spring and its upward movement was limited by a stop adjustable by the operator. If the pump gains on the flow over the weir the liquid level behind the weir falls, the water pressure above it is unbalanced and the weir crest descends by extending the spring. More liquid then flows over the lowered weir, the liquid level behind the weir rises, the water pressure is balanced, the weir rises to its stop and the former condition is restored.

The receiving vessel was a rectangular tank of capacity about 70 gallons so fixed that most of its volume was below water level. The tank had a perforated floor above which was a set of baffles and it rested filled with water to the level of the outside surface. The mixture of water and oil from the sump was pumped into the tank through a perforated pipe a short distance above the baffles. The oil rose to the surface of the receiving tank and the water passed through the holes in the bottom.

When the receiving tank was full of oil the same pump passed it through alternative suction and delivery pipes to another receiving tank ashore or on a barge. This second tank then contained oil from which most of the water had been removed. It was proposed that the machine should be self-propelled or lashed ahead of a motor launch to move it from point to point and control its position when skimming oil.

The machine works successfully and a second one is now under construction for regular work.

The Hopper Dredge

Its History, Development and Operation

A Review of a Publication by the Office of the Chief of Engineers, U.S. Army.

(Concluded from page 294)

Gas Removal Systems.

When materials containing a considerable amount of entrained gas are encountered, some of this gas is liberated in the suction assemblage of the dredge and may accumulate in such quantities that the volume of solids discharged by the pump is reduced or completely stopped.

The New York District of the Corps of Engineers carried out preliminary work which demonstrated this effect and developed the first equipment which was successful in removing gas from the system and preventing the pump from losing its suction.

Amount of Gas Removed

The section dealing with the assessment of the capacity of the gas removal system will be quoted almost in full:—

"The first gas removal system, installed on the 'Atlantic' in 1946, consisted of a simple steam jet ejector which had its suction connected to the top of the dredge pump suction pipe near the pump and its discharge piped overboard. Several trials finally led to the selection of an ejector which achieved the desired results; closing its steam valve resulted in practically complete loss of discharge from the dredge pump; opening the valve restored the discharge. This ejector, designated 'A,' which had a rating of 240 cfm at 20-in. of vacuum, restored the output of the dredge pump, after unloading, by removing approximately 135 cubic feet of gas per minute from and at the existing 10-in. of vacuum.

"The pumping rate of the 'Atlantic' was found to be very sensitive to change of dredge speed. In order to eliminate this factor in determining the efficacy of ejectors of various sizes, the two dredge pumps were fitted during each trial with ejectors of different sizes, and one pump discharged into the forward hoppers while the other was discharged into the after hoppers. From data obtained the conclusion was reached that ejector 'A,' with a rating that compares closely with the volume obtained by expanding the 135 cfm from 10-in. to 20-in. of mercury, was adequate for the 'Atlantic' in Bay Ridge Channel, New York Harbour, at that time.

"By this method, the required capacity of gas ejection equipment was roughly established. In order to make a laboratory check of this capacity, a number of gas samples were obtained from current dredging areas in the North Atlantic Division. From analyses of these gases, it was ascertained that the most soluble gas which might be encountered would be a combination of 85 per cent. methane (CH_4) and 15 per cent. carbon dioxide (CO_2). On the basis of solubility only, and assuming that the water content of mud is a saturated solution of this hypothetical gas, without free gas in the form of bubbles, the gas content was computed for the following conditions:

(a) 50-ft. depth.
(b) Mud temperature 10° C.
(c) Water content of bottom sample of mud 70 per cent. by volume.
(d) Solubility of gas 87.5 per cent. of that in fresh water, due to salt and other minerals dissolved.
(e) 60 per cent. of the gas released from solution at 20-in. of vacuum requires removal.

"Computations indicate that at 20-in. of vacuum, about 3.9 cubic feet of gas, measured at atmospheric pressure, would be released for each 100 cubic feet of mud, and should be collected. Using this factor and applying the proper constants, the following formula is derived:

$$Q = .0383\ VD^2$$

where

Q = cfm of gas to be removed from the suction pipe; volume corresponding to a vacuum of 20-in. of mercury.
V = Velocity in suction pipe in fps.
D = Diameter of suction pipe in inches.

"The above formula applied to the 'Atlantic,' which has a suction pipe diameter of 19½-in., assuming a velocity of 20 fps, gives 290 cfm of gas to be released from each pipe. This is about 20 per cent. above the comparable capacity of ejector 'A' which was used successfully on this dredge.

"Dredge experience with the 'Atlantic,' 'Essayons' and 'Goethals' indicates that ejectors having capacities determined by the above formula are approximately correct, although none of these vessels has dredged material of high gas content except during limited tests periods. Measurements while dredging mud do not show actual velocities in the suction pipe as high as 20-ft. per second, the highest indicated velocity having been 16-ft. per second while dredging material of low gas content. Usual velocities while pumping economic loads of material with high gas content have been below 10-ft. per second. These pumped mixtures have ranged in density from 1.25 to 1.40, with vacuum varying from about 12-in. to 26-in. of mercury. Because of the wide variations in conditions encountered, it is considered that the values found by the formula using a maximum velocity of 20 fps. are generally satisfactory for determining the size of gas removal equipment, even though the possibility of free gas being present has been disregarded."

Table 5 details the computed vacuum pump sizes for various sea-going hopper dredges.

Analysis of gas samples from the New York and Philadelphia Districts shows the

Dredge.	No. of dredge pumps	Suction pipes per pump		Estimated Max. volume of gas at vacuum and suction pipe velocity			Rotary vacuum pump ②			High Efficiency Steam ejector approx lbs steam per min. ②
		No.	Dia. ins.	CFM	Vac. ins mercury	Vel. ft. sec. ①	Rated capacity at vac, cfm.	Size ins.	Hp. required	
ESSAYONS	2	1	36	1000	20	20	1290	8	100	....
GOETHALS	2	1	32	780	20	20	660	6	60	....
COMBER Class	2	1	30	690	20	20	660	6	50	28
MACKENZIE	1	2	24	660	20	15	660	6	50	....
KINGMAN Class	1	1	26	520	20	20	660	6	50	....
MICHIE	1	1	26	520	20	20	660	6	50	22
NEW ORLEANS	2	1	26	360	17	20	370	4	30	16
HARDING	2	1	22	370	20	20	360	4	30	....
HAINS Class	1	2	18	370	20	15	360	4	30	....
PACIFIC	1	2	18	370	20	15	360	4	30	....
TAYLOR	2	1	15	170	20	20	240	3	20	10

① In each suction pipe. ② For each dredge pump.

Note:- The vacuums and velocities are assumed and are not necessarily those that obtain after installation of the equipment. Actual values depend on the characteristics of the dredge pump and its piping and of the material being pumped.

Table 5.

Hopper Dredge—continued

gases to be a mixture of Carbon Dioxide (content varying from 1 per cent. to 14.6 per cent), Oxygen (0.4 per cent. to 12.1 per cent.), Hydrogen (0.6 per cent. to 29.8 per cent.), Methane (0 per cent. to 85.3 per cent.), Nitrogen (0.2 per cent. to 89.8 per cent.), Other Gases (0 per cent. to 1.6 per cent.). Many of these mixtures are explosive. The most soluble gas is carbon dioxide and the next methane. From the percentages given it follows that the most soluble gas likely to be encountered is a mixture of 85 per cent. Methane and 15 per cent. Carbon Dioxide, which has a solubility at 10° C. of approximately 4.9 per cent. by volume for each atmosphere of pressure. This value has been used in determining the capacity of gas removal equipment.

Types of Gas Evacuators.

As well as steam ejectors, vacuum pumps or water ejectors are used in gas removal systems. Whichever type is used it should preferably be fully automatic, starting and stopping with the dredge pump. Instruments in the pilothouse to indicate that the system is in operation are essential.

The rotary liquid piston type vacuum pump can be used on any dredge. Because of the high initial cost of this type of pump, protective devices should be provided to prevent the pumping of solids with resulting damage or wear. This also applies to high efficiency steam ejectors. With the latter there is a minimum steam pressure for each set of suction and discharge conditions below which the ejector ceases to function as a vacuum pump. An increase above the optimum pressure increases steam consumption and slightly reduces the ejector capacity. Therefore the ejector steam pressure should be maintained slightly above the minimum needed for the most adverse suction and discharge conditions expected.

With low efficiency steam ejectors, which are used principally on low pressure steam dredges using water for boiler make-up, no protective devices are needed to guard against pumping solids. The use of water ejectors is, in general, economically justifiable only when the required water pumping capacity is already installed.

The gas removal system in the "Comber" is illustrated in Fig. 30. The system in the "Goethals" is similar but in the former high efficiency steam ejectors are used, whereas the latter employs a rotary liquid vacuum pump.

The effect of gas removal on such factors as admission of water, dredging speeds, types of drags, etc., require further investigation.

Economic Loading.

The short chapter on economic loading is of particular interest not only because of the information given, but because it illustrates the scientific approach applied to an activity which, at first sight, appears unsusceptible to such an approach. With the kind permission of the Office of the Chief of Engineers, Washington, D.C., it is quoted in full.

General.

"Economic loading of a hopper dredge is based on the determination of that pumping time, which in each case, results in removal of the maximum amount of material in a day's operations. The following factors constitute the effective working time of a hopper dredge and must be taken into account in making the determination:

a. Time spent loading the hoppers.
b. Time spent turning around between cuts.
c. Time going to and from the dump ground.
d. Time required for dumping the load.

For any particular dredging project, factor b is usually constant and is primarily dependent on the length of the cut and the manoeuvrability of the vessel. Factor c is fixed by the distance to the dump ground and the speed of the dredge. This factor likewise is usually constant except when heavy traffic, poor visibility or rough seas necessitate a reduction in the running speed. Factor d is determined by the character of the dredged material and ordinarily is also constant for any given project. Factor a, therefore, is the only one susceptible to variation in the interest of improving dredging economy."

"Determination of the economic loading time is of greatest importance in dredging slow-settling materials such as silt, mud, mixtures of mud and silt and fine sand, since these often require an inordinate amount of pumping time in order to obtain full loads of settled solids. The two limits of loading a hopper dredge are to pump until the hoppers are completely filled with settled solids, or to pump only until the hoppers start to overflow. Loading under the first procedure, depending on the character of material dredged, may require hours of pumping time compared to minutes for the second procedure. The economic loading or pumping time lies between these two extremes."

"The principles of economic loading of a hopper dredge were not put in practice until 1922 when a simple method of determining the percentage of suspended solids in mud and mud-sand mixtures was developed. Before this time, hopper dredges were usually operated on fully loaded hopper schedules. This procedure was satisfactory for coarse sand or other quick-settling material, but was inefficient and uneconomical when applied to slowly settling materials."

Development.

"In 1920 it was observed that the dredge "Burton," then handling slow-settling materials in Cleveland Harbour, could increase its daily output of solids by dredging only partial loads under a shortened pumping schedule. Settlement of solids in the hoppers took place so slowly that only two loads of 720 cubic yards each of settled solids could be obtained in the 9-hour period, even though the hauling time to the dump ground and return was only 30 minutes per load. This unsatisfactory operation led to the thought that the daily ouput of the dredge might be increased by shortening the 4-hour loading time and making more loads, composed of less settled solids, and more solids in suspension. This posed the question of whether the percentage of solids held in suspension in the mixture above the settled solids was sufficient to justify the reduction in pumping time required for the extra loads. Computations showed that if the "Burton" dredged additional loads and the percentage of solids in suspension was 8.76, the loss in settled solids would be exactly balanced by the gain of solids in suspension. It followed that the output of the dredge could be increased by dredging more than two loads a day, if the percentage of solids in suspension in the hoppers exceeded 8.76 per cent."

"This percentage expressed in decimal

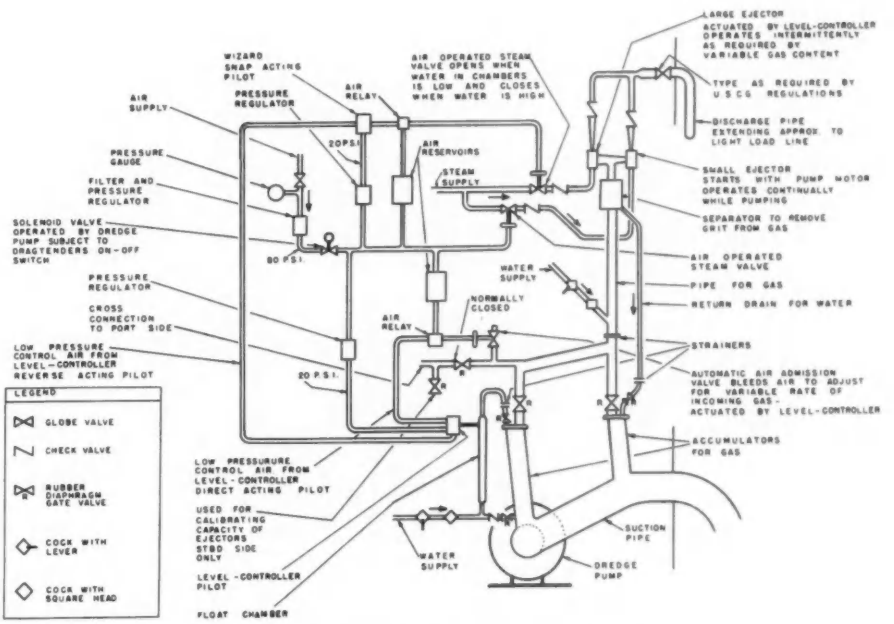

WIZARD SNAP ACTING PILOT
AIR SUPPLY
PRESSURE REGULATOR
AIR RELAY
AIR OPERATED STEAM VALVE OPENS WHEN WATER IN CHAMBERS IS LOW AND CLOSES WHEN WATER IS HIGH
LARGE EJECTOR ACTUATED BY LEVEL-CONTROLLER OPERATES INTERMITTENTLY AS REQUIRED BY VARIABLE GAS CONTENT
TYPE AS REQUIRED BY U.S.C.G. REGULATIONS
DISCHARGE PIPE EXTENDING APPROX. TO LIGHT LOAD LINE
PRESSURE GAUGE
FILTER AND PRESSURE REGULATOR
20 P.S.I.
AIR RESERVOIRS
STEAM SUPPLY
SMALL EJECTOR STARTS WITH PUMP MOTOR OPERATES CONTINUALLY WHILE PUMPING
SEPARATOR TO REMOVE GRIT FROM GAS
SOLENOID VALVE OPERATED BY DREDGE PUMP SUBJECT TO DRAGTENDERS ON-OFF SWITCH
80 P.S.I.
AIR OPERATED STEAM VALVE
PIPE FOR GAS
RETURN DRAIN FOR WATER
WATER SUPPLY
NORMALLY CLOSED
PRESSURE REGULATOR
CROSS CONNECTION TO PORT SIDE
AIR RELAY
STRAINERS
LOW PRESSURE CONTROL AIR FROM LEVEL-CONTROLLER REVERSE ACTING PILOT
20 P.S.I.
AUTOMATIC AIR ADMISSION VALVE BLEEDS AIR TO ADJUST FOR VARIABLE RATE OF INCOMING GAS - ACTUATED BY LEVEL-CONTROLLER
ACCUMULATORS FOR GAS
LEGEND
GLOBE VALVE
CHECK VALVE
RUBBER DIAPHRAGM GATE VALVE
COCK WITH LEVER
COCK WITH SQUARE HEAD
LOW PRESSURE CONTROL AIR FROM LEVEL-CONTROLLER DIRECT ACTING PILOT
USED FOR CALIBRATING CAPACITY OF EJECTORS STBD SIDE ONLY
SUCTION PIPE
WATER SUPPLY
DREDGE PUMP
LEVEL-CONTROLLER PILOT
FLOAT CHAMBER

Fig. 30. Dredge "Comber"—gas removal system.

Hopper Dredge—continued

form is called the critical ratio and the formula used for determining it is:

$$R_c = \frac{ST}{V+ST}$$

where

Rc=critical ratio.

S=number of cubic yards of settled solids obtained per pumping minute.

V=total capacity of hoppers in cubic yards.

T=non-pumping time in minutes per load, i.e., the time required for turning between cuts, going to and from the dump ground and for dumping.

" Theoretically, the critical ratio is that percentage of solids in suspension which with an increased number of loads will give a daily output equal to that which would be obtained by dredging a lesser number of full loads, provided the settled solids rate per minute of pumping time remains constant. If then the percentage of solids held in suspension in the hopper mixture is above the critical ratio, more material will be obtained by reducing the pumping time per load to a minimum and dredging as many loads per day as is practicable."

" The conception of critical ratio has had a major effect on the economic aspect of dredging, but has no direct application in the solution of a problem in economic loading. This must be done experimentally by measuring the amount of solids actually precipated and held in suspension for different lengths of pumping time and must be done for each individual project."

" The usefulness of the " Burton " economic loading studies was limited by the lack of a simple method of determining quickly and with reasonable accuracy the percentage of solids in suspension. Such had not been devised by the time the dredge completed its work in Cleveland Harbour. The San Francisco District, Corps of Engineers, faced with the difficult job of maintaining project depths in Mare Island Strait and Pinole Shoal Channels with the 500 cubic yard dredge " San Pablo," in 1922 continued economic load studies. In the course of these, there was evolved a simple weight method which enabled immediate measurement of solids carried in suspension, which placed the determination of economic loading time for dredging mud or mud-mixture material on a practical basis. This method, with variations which are described later in this section, is still in use."

" A formula for determining the actual economic pumping time was introduced in 1923. This formula is as follows:

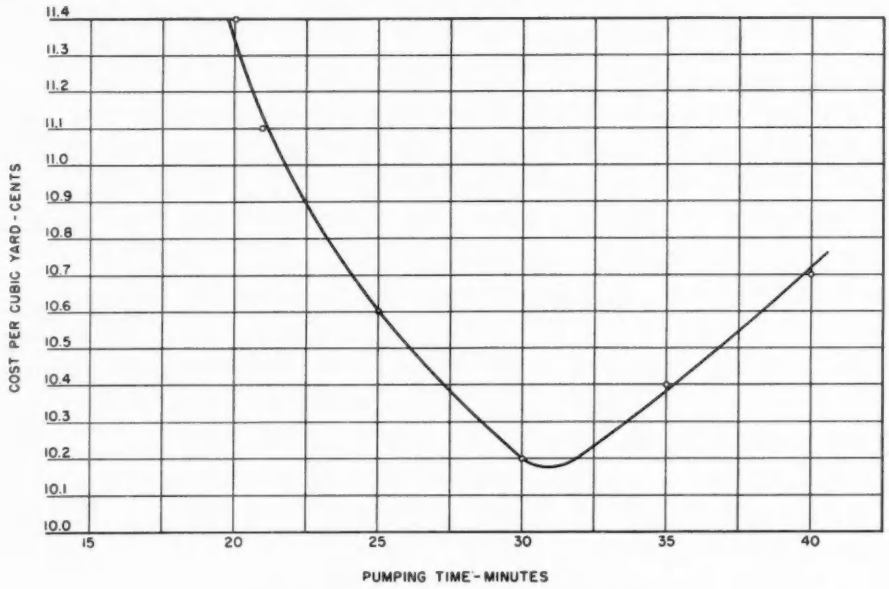


Fig. 31. Typical economic load curve.

$$C_y = \frac{(T+t)C_m}{Y}$$

Cm=operating cost of the dredge per minute of effective working time.

t =pumping time, minutes per load.

T =non-pumping time (i.e., turning, dumping, running to and from dump) in minutes per loads.

Y =number of cubic yards of solid material in hoppers in each load, including settled and suspended solids.

Cy=cost per cubic yard of solids dredged and dumped.

For any particular dredging assignment, T is a constant. Cm, the operating cost of the dredge per minute, is also a constant and, if not immediately available, can be an estimated value without affecting the determination of economic pumping time. The load Y is measured and must include both settled and suspended solids. Several loads are dredged, using different pumping times, and the results, found by applying the formula, are plotted with cost per cu. yd. (Cy) as ordinates, and pumping time (t) as abscissae. A curve drawn through the points will show the pumping time which will give the lowest cost per cubic yard for this set of conditions. The curve will be similar to that shown in Fig. 31."

" A simplification of the above formula may be made by omitting the cost factor whereupon the formula becomes:

$$X = \frac{Y}{T+t}$$

where X is the number of cubic yards dredged per minute of effective working time. The results can be plotted as before and the most economical pumping time determined."

Measurement of Hopper Loads.

" The amount of settled solids in the hoppers is measured by sounding after pumping is stopped. A weighted disc attached to the end of a light line is used for the purpose. The standard disc is 6-in. in diameter, weighs 2 pounds 2 ounces and is assumed to come to rest at the top level of the settled solids. Two or more soundings are made in each hopper, and the solid content thereof in cubic yards is read from a hopper capacity curve or from yardage tables prepared for the dredge."

" Simultaneously with the soundings, the mixture above the plane of settled solids is sampled. A special rig developed for this purpose, having a 1-quart bottle fitted with a stopper operated by an extension rod, is lowered to a point half-way between the top of each hopper load, and the level of the settled solids. The bottle is secured to the lower end of a graduated rod, and after it is lowered to the proper depth, the stopper is lifted, the bottle fills with the mixture at that depth, and then is again stoppered. All samples thus obtained are thoroughly mixed to produce an average sample representing the percentage of suspended solids in the load. The yardage of solids in suspension in the load is computed by multiplying the hopper content less the settled portion by the average percentage of solids in suspension. The total cubic yards of solids in the load is considered to be the sum of the settled solids and the solids in suspension determined by the above procedure."

" One method for determining the percentage of suspended solids consists of weighing a beaker filled with the average sample on an ordinary two-plate balance scale having a horizontal beam graduated from 0 to 100, and a movable pendant weight on the beam. The sample is balanced on the weighing scale by moving the pendant weight along the beam. The reading of the scale at the pendant weight position then shows directly the percentage of solids in the sample."

" Zero per cent. graduation on the beam is determined by placing the beaker filled with sea water on the left-hand plate of the scale with the pendant weight near the left-hand end of the beam. On the right-hand plate sufficient weight is added to balance the scales. The position of the pendant weight then registers zero per cent. and the beam is so marked. One hundred per cent. gradua-

Hopper Dredge – continued

tion on the beam is set by placing the beaker filled with 100 per cent. bottom material on the left-hand plate and moving the pendant weight to the right until the scales are in balance. The pendant weight position then registers 100 per cent. and the beam is so marked. Having thus determined the zero and 100 per cent. points on the beam, the intervening space is evenly divided into the desired graduations."

"The material for determining the 100 per cent. point should be taken from the channel bottom as undisturbed as possible, preferably by a sampling device, then carefully packed into the beaker so as to exclude air pockets."

"A modification of the above method consists of weighing a 1-litre (1,000 cubic centimetre) sample of the average mixture on a very sensitive balance. The weight in kilograms equals, directly, the apparent density of the sample. The percentage of solids can then be determined either by referring to a chart based on the density of the bottom material under consideration, or by applying the following formula:

$$\% \text{ Solids} = \frac{100\ (M-A)}{B-A}$$

where

M = Weight of mixture sample in kilograms.
B = Weight of bottom material sample in kilograms.
A = Specific gravity of the water in which the solids are suspended.

For practical purposes, A may be taken as unity, so that the formula becomes:

$$\% \text{ Solids} = \frac{100\ (M-1)}{B-1}$$

"A device known as the yardage meter has recently been developed by the Corps of Engineers and tried experimentally on the "Essayons." This device, which measures the increase in draft of the vessel as it is loaded, can be calibrated to read in tons of solids loaded in hoppers or directly in cubic yards when the density of the bottom material is known."

"The apparatus consists essentially of one or more orifices located in the ship's bottom through which air is expelled, a compressed air supply and a pressure gauge. The deeper the orifice is submerged, the higher becomes the pressure required to expel the air. This pressure is read on the gauge and is commensurate with the tonnage displacement of the vessel."

"This instrument has the advantage that it measures not only the settled solids but those in suspension and gives a continuous indication of the amount of material collected in the hoppers. Economic loading is thereby very much simplified, and the daily yardage hauled by the dredge can be determined without sounding and sampling."

"While it is too early at this writing to say that the yardage metre will entirely displace the methods previously described of determining the output of hopper dredges, it holds great promise and experiments with it are being continued."

Overflow Losses.

"After the hoppers are filled to the overflow level with the mixture of water and solids as pumped, some of the mixture passes overboard with the overflow. Much can be learned by determining the percentage of solids in the overflow. The percentage in the mixture as pumped can be ascertained by extracting samples of the pump discharge, preferably from a sampling valve on the riser from the pump, and determining the percentage of solds in the manner described in the preceding article. The percentage in the overflowing mixture can be ascertained likewise by taking samples simultaneously at various representative points along the overflow troughs and mixing them to form an average sample."

"If the material being dredged is of a type that settles readily, like coarse sand and gravel, then the percentage of solids in the overflow will be practically nil and the hoppers will be filled to the top without appreciable loss of solids. On the other hand, if the two percentages are nearly equal, it is obvious that the solids are settling so slowly that complete filling of the hoppers with settled solids would be wasteful and an economic load study is indicated."

"The above discussion of economic loading presupposes that the vessel speed while dredging and the pump speed are the optimum for the material which is being dredged. As both of these factors have an appreciable effect upon the amount of solids which are procured and retained, it may be necessary to extend the economic load studies to include them if a previous determination has not been made."

Agitation Dredging.

"Circumstances are sometimes encountered where economic loading of a hopper dredge does not result in the most rapid removal of the material from the project area. It has been found in many instances that solids passing overboard through continued pumping after the economic load is obtained, drift away and are deposited outside of the channel in quantities which more than compensate for the hopper yardage which is lost. An operation of this kind is called agitation dredging."

"The conditions under which agitation dredging becomes advantageous are difficult to determine. First, the material being handled must be of such a character that it will not immediately settle, and secondly, there must be a current in the surrounding water which will carry the material beyond the channel limits. Favourable conditions may exist at any particular project only at certain times of the day, such as ebb tides, or only at such periods when the stream flow is above a given amount. To make the most of agitation dredging, therefore, requires exhaustive study of the local conditions and considerable experimentation with the particular dredge that is employed."

"There is a theoretical approach which may give some indication as to whether agitation is feasible or not. This involves first, a screen analysis of the material to determine the proportion of solids of various grain sizes. Then investigations of velocity and direction of prevailing water currents, distance through which the material must be carried to be deposited outside the project area, and the depth of water where it is to be deposited. With this data, the percentage of solids that will come to rest outside the channel limits can be found by the use of a chart such as that shown in Fig. 32."

"If a theoretical analysis is made, and it indicates that agitation dredging may be economical, further experiments are required to find the extent to which it should be carried to obtain optimum results."

"When agitation dredging is employed, the lower overflows, if suitable, are used to minimise the hopper load and attain maximum manoeuvrability of the vessel, and pumps are operated at maximum speed to obtain as high a percentage of solids as possible."

"It has been found necessary in most cases to dump the solid material accumulated in the hoppers at intervals; otherwise it becomes compacted to such an extent that it is extremely difficult to remove. The overall operation therefore involves a certain amount of hauling as well as agitation. An equitable division of costs between the two operations should be made, based on the yardage removed from the channel by each method in order to establish the relative merits of agitation versus economic loading."

Dredging Coarse Sand, Gravel, etc.

"Materials such as coarse sands, gravel, stones, etc., which settle readily in the hoppers to about the same constituency as found in place on the channel bottom, do not present a difficult economic loading problem. The unit cost curve for such material will drop steadily until the hoppers are completely filled."

"Usually a load of coarse sand is most quickly obtained by operating the dredge pumps at maximum revolutions per minute, running the dredge over the cut at optimum dredging speed, and by care in distributing the dredged mixture so that the various hoppers fill simultaneously. The percentage of solids in the pumped mixture increases as the hoppers fill and the dredge settles deeper into the water. The improvement continues during the entire time solids are accumulating in the hoppers and reaches a maximum when the hoppers are filled with solids and the dredge is at its deepest draft. This is explained by the fact that the dredging pump is lowered with reference to the water level as the dredge settles deeper into the water. Consequently the height to which the dredged material must be lifted is decreased and the available vacuum therefore is able to lift increasingly denser mixtures. For this reason, it is usually advisable when handling sand, gravel, etc., to have the hoppers filled with water before dredging is started."

Dredging Fine Sands.

"Fine sands from a dredging viewpoint are those composed of grains 0.5 mm. or less in size. These sands settle in water much more slowly than coarse sands and those having angular shaped grains pack into a

Hopper Dredge— continued

dense hard mass in the hoppers. This condition makes the dredging of such sands especially difficult because of the minute water spaces between the individual grains of the bed mass. Retention of fine sands in the hoppers is also difficult because their slow settling rate causes much of the solid material in the mixture pumped into the hoppers, to pass overboard with the overflow. It becomes important, therefore, to establish the r.p.m. of the dredge pumps that will effect the maximum rate of retention in the hoppers. The percentage of solids in the pump discharge and in the material overflowing the hoppers should be determined at several pump speeds and that speed selected which will result in the minimum pumping time required for the economic load. This determination should be made for loads dredged with and without first filling the hoppers with water."

" Because of the difficulty occasionally encountered in dumping material of this character, it may be found that the time consumed in this operation will have an appreciable effect on the economic load. A partial load which has had less time to consolidate and is subject to lower compaction pressure may dump in only a small fraction of the time required for a full load. This, combined with the shorter pumping time needed to partially fill the hoppers, will sometimes make such procedure economical."

Mud and Silt Dredging.

" Some muds, especially when lumpy, settle readily in the hoppers, while others do not. Silt settles very slowly, some of the finer particles remaining suspended for hours. Therefore when dredging these materials the determination of economic loading is of great consequence. In some instances the pumps may be operated for long periods and only small quantities of settled solids will accumulate in the hoppers and the pumping time will be excessive if full loads of such material are obtained. A comparison of the percentage of solids in the overflow and in the mixture as pumped will give an indication as to when this condition prevails. In extreme cases, the most economical procedure is to unwater the hoppers; if practicable, pump a mixture containing the maximum percentage of solids and stop pumping as soon as the hoppers are filled."

" After a load is dumped and the hopper doors are closed, water becomes trapped in the hoppers up to the light draft of the dredge. There is no objection to the presence of this water when the material being dredged settles readily, for it is soon displaced by the solids. However, when materials that do not settle readily are pumped, especially when the schedule calls for pumping only until the hoppers start to overflow, this residual water dilutes the load and the performance of the dredge can be improved by removing all water from the hoppers before dredging begins. It is with this type of material that agitation dredging is most apt to be advantageous."

Mud and Sand Mixture Dredging.

" On some dredging projects, the material consists of a mixture of mud and sand. The economic load determination for such mixtures is just as important, if not more so, than for mud alone where some of the solids escaping with the overflow settle outside the channel. When a mixture of mud and sand is dredged, any sand overflowing the hoppers is usually redeposited quickly and pumping should be stopped as soon as the economic load has been obtained."

" When handling material of this character, it is difficult to accurately determine the percentage of solids held in suspension in the hoppers in terms of bottom density because of the lack of uniformity of the latter."

" In operations on Pinole Shoal Channel, San Pablo Bay, California, the following method was used for the determination of percentage of solids for sand and mud mixture material:

1. A sample of sand-free mud was obtained and weighed.
2. A scale beam graduation was made as previously described, using the weight of the above sample for its 100 per cent. point and the weight of a sample of clear channel water of the same size for the zero point.
3. Several samples of the mixture lying above the settled solids, taken after dredging in various parts of the project, were procured.
4. Each sample was diluted with three parts of clear channel water and poured into a 3-in. diameter graduated glass cylinder. The sand content quickly precipitated and its height in the cylinder was noted. The

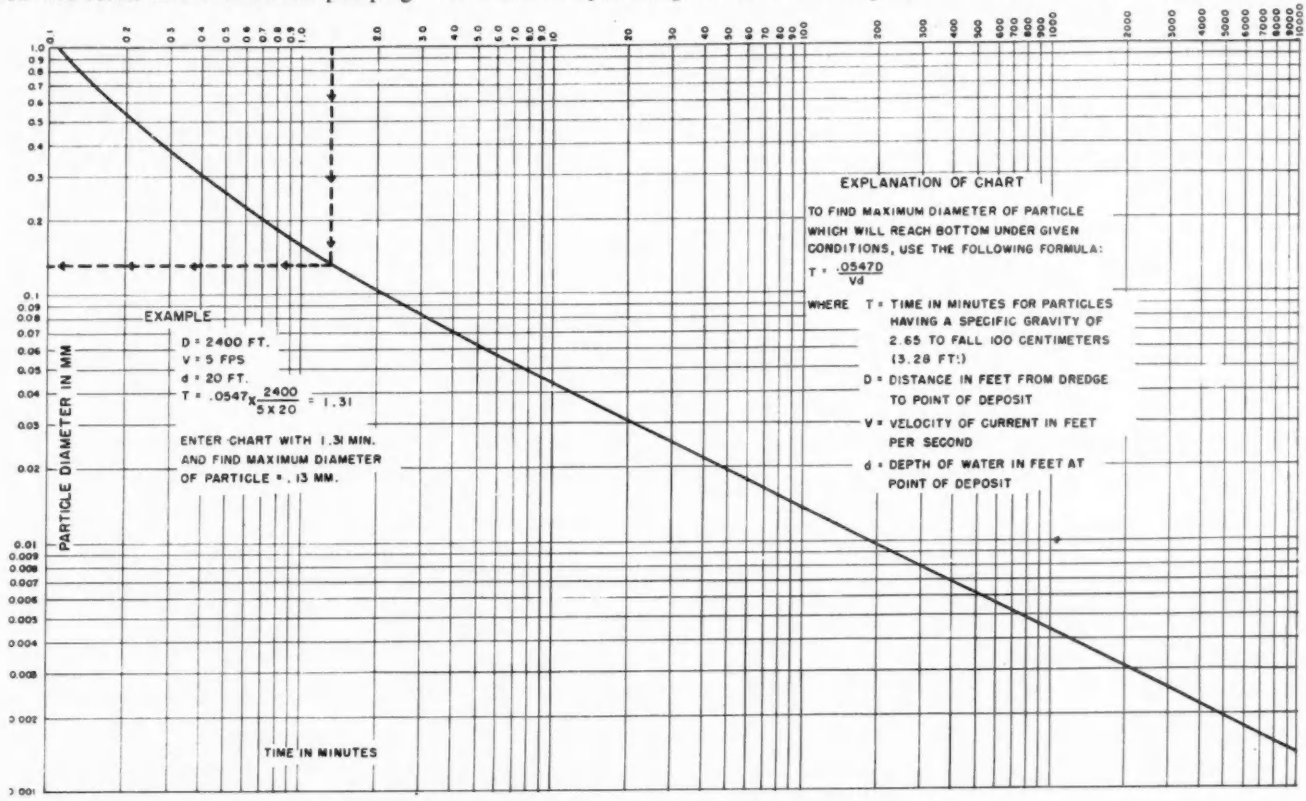

PARTICLE DIAMETER IN MM
TIME IN MINUTES
EXAMPLE
D = 2400 FT.
V = 5 FPS
d = 20 FT.
T = .0547 x 2400/5x20 = 1.31
ENTER CHART WITH 1.31 MIN.
AND FIND MAXIMUM DIAMETER
OF PARTICLE = .13 MM.
EXPLANATION OF CHART
TO FIND MAXIMUM DIAMETER OF PARTICLE
WHICH WILL REACH BOTTOM UNDER GIVEN
CONDITIONS, USE THE FOLLOWING FORMULA:
T = .05470/Vd
WHERE T = TIME IN MINUTES FOR PARTICLES
HAVING A SPECIFIC GRAVITY OF
2.65 TO FALL 100 CENTIMETERS
(3.28 FT.)
D = DISTANCE IN FEET FROM DREDGE
TO POINT OF DEPOSIT
V = VELOCITY OF CURRENT IN FEET
PER SECOND
d = DEPTH OF WATER IN FEET AT
POINT OF DEPOSIT

Fig. 32. Chart for determining largest grain sizes to reach deposit area.

Hopper Dredge—continued

different samples gave varying heights, in this case, 0, ¼-in., ½-in. and ¾-in.

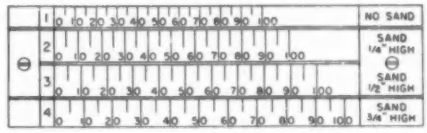
5. The liquid was decanted from each sample and the sand placed in the original sample container. The latter was then filled with sand-free bottom material. The samples thus obtained were weighed and formed the basis for establishing the 100 per cent. points on the scales corresponding to various heights of sand in the graduated cylinder. In this case, four scales were devised as shown in Fig. 33."

"After the scales had been established, each sample of dredged mixture lying above the settled solids was first weighed, then diluted and placed in the graduated cylinder to determine the category to which it belonged. The percentage of suspended solids was then read from the nearest applicable scale."

"While this procedure is somewhat cumbersome, it gave good results and is more accurate than assuming an average density for the bottom material throughout the project."

Unusual Dredging Accomplishments.

The final chapter gives accounts of unusual projects, seven in the Atlantic Ocean and Gulf of Mexico Waters, and eight in Pacific Ocean Waters. These accounts, in which difficulties and hazards successfully overcome are clearly related, are well worth careful study but because of their conciseness they cannot be rendered in precis. It will suffice here to quote from the introduction to the chapter to the effect that these projects "demonstrate clearly the versatility of the hopper dredge, the care, experience and ability exercised in the design and construction of these vessels, the interest, industry and efficiency of supervisory personnel and the skill, courage and resourcefulness of the crews."


NO SAND
SAND 1/4" HIGH
SAND 1/2" HIGH
SAND 3/4" HIGH
NOTE
FRACTIONAL HEIGHTS ON SCALE SHOW CONTENT OF SAND IN A WEIGHED HOPPER SAMPLE AFTER DILUTION, AS MEASURED IN A 3" DIAMETER GLASS TUBE
Fig. 33. Beam scales for mud and sand mixtures.

The publication, which is fully indexed and admirably illustrated, contains four appendices, 218 figures and 33 tables.

Provestenen Oil Port

Improved Facilities for Copenhagen

by J. G. Rode, Chief Engineer and A. R. Lamm, Deputy Chief Engineer, Port of Copenhagen Authority.

The name "Prøvestenen" (meaning "the touchstone") was originally applied to an old fortress built on three ships of the line sunk near the entrance to Copenhagen in 1802. This fortress lasted until 1828, when it was demolished without being replaced. The existing fort was erected in 1859-63 and is a far more solid structure, built of concrete with casemates and equipped with the most important asset of a small harbour.

This small haven attracted the attention of the Port of Copenhagen Authority when, about twenty years ago, they were looking for a favourable place in which to store their rapidly expanding oil imports. From the point of view of city planning, it seemed wise to concentrate as many oil installations as possible at this island, which is situated quite a distance from the residential areas and is yet comparatively close to the town. However, there were also advantages in the dispersal of the dangerous material over several smaller oil dumps. Finally is was decided to use Prøvestenen as the main oil storage and in 1935 work was begun on the first part of the installation.

Tankers of up to 25,000 ton d.w. approach Prøvestenen from the "Kattegat" through "Oresund" and "Kongedybet," passing east of the main port of Copenhagen and off the island of "Amager," to which Prøvestenen is connected by two bridges. The approaches are easily navigable and well marked with lighthouses and buoys. Severe winters are infrequent, but when they do occur, the port can be kept open with the use of ice-breakers. Since there is no tide Prøvestenen, like the main port, is an open harbour with a variation in depth of only ± 2 ft., except in extreme cases.

The first stage of the development comprised 25 acres of land with a tank capacity of 27,000,000 imperial gallons, but soon after the Second World War this capacity was found to be too small and in 1950 a further reclamation was decided upon. During the years 1951-54 Prøvestenen was developed to its present size of about 80 acres of land, on which tanks containing some 60,000,000 gallons of oil have already been built. When the whole area is utilised the tank capacity could be almost doubled.

The old shallow fortress-port has disappeared and has been replaced by a modern harbour with a depth of 34 ft. 5 in. in the outer harbour, 29 ft. 10 in. in the inner, and 16 ft. 6 in. in the small sheltered harbour. The corresponding lengths of the quays are 1,400 ft., 1,750 ft., and 650 ft., the height being 7 ft. 3 in. above the level of the sea, allowing the berthing of vessels up to 25,000 ton d.w. Most of the wharves have been constructed of steel sheet piling, Belval BZ 4 N, and are protected by timber fenders.

Wave model tests showed that strong winds from the north-east could raise a swell, particularly along quay No. 4, which is the only one directly facing north-east. In order to diminish the wave action, a part of this quay has been constructed of a vertical steel sheet piling from the sea bottom to about 15 ft. below the surface level of the sea, and from there onwards boulders are made to form a glacis on which the oncoming waves expend their energy and do not form stand-

View of part of the main port of Copenhagen shewing Provestenen in the background.

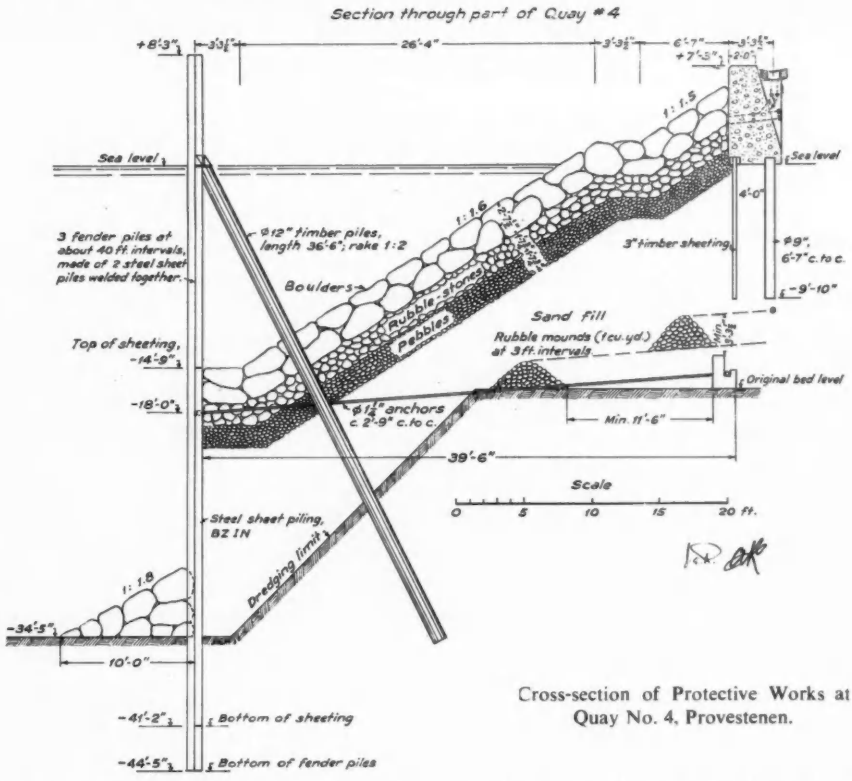
Provestenen Oil Port—continued

ing waves. Although fierce storms and hurricanes are unknown in Copenhagen, a small shelter has been provided inside the harbour where coasters can seek refuge from the wind.

Apart from the building of the actual oil harbour, the development has included the building of two reinforced concrete bridges, connecting Prøvestenen with the island of Amager, the north-eastern part of which is a part of Copenhagen, and the construction of roads, sewers, light, water mains, etc. The sewage system consists of storm sewers carrying the rain water direct into the sea, and a net of pipes collecting the sewage to a pumping station which discharged into the main municipal sewage system.

Water mains carry water from the municipal water works to the different oil companies and to the fire hydrants. However, as the pressure in these water mains is not sufficient for fire fighting purposes they are supplemented by a pumping station delivering sea water through a separate system of pipes furnished with special fire hydrants. This station draws sea water from an inlet 11 ft. below the level of the sea and pumps it at the rate of 80 cu. ft. per minute under a residual pressure of 140 lbs. per sq. in. at the most remote hydrant, while liquid for making foam can be delivered to the different tanks through still other pipe lines. The sea water pump is driven by two 220 h.p. diesel engines coupled together and the foam pump is powered by a 350 h.p. electro-motor. By means of valves the two systems can be operated so as to carry alternately water or foam, both together. The electro-motor can be started automatically by pushing the button on any of the many fire alarm posts. This action also alerts the municipal fire brigade and sets off the oil port sirens.

Heating of the building and mixing plants is done by steam from five boiler houses, three of which belong to the oil companies and two to the port.



Cross-section of Protective Works at Quay No. 4, Provestenen.

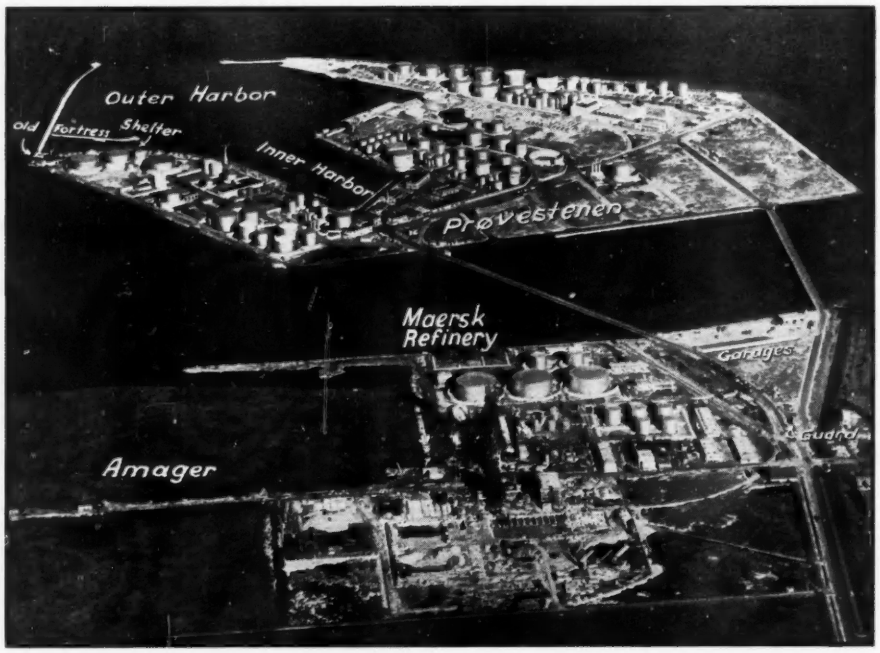
The reclamation of the land and the construction of the harbour with the wharves, bridges, roads, sewers, light, water, and fire precaution were designed and built by the Port of Copenhagen Authority. The different oil companies have erected their own installations on land rented from the Port Authority. All the oil tanks are above ground level and made of steel plate and in some instances insulated by lightweight masonry to diminish evaporation.

The oil is pumped direct from the ships along the wharves through subterranean pipe lines into the tanks, from which it is delivered through racks to either railway wagons or motor lorries for final despatch. Most of the trucks are parked off the island port in open-air garages, where the engines are kept warm by electrically heated plugs inserted in the cooling water during the night. The oil port is fenced off and closed to the public, and there is guard over the only access road on the shore which leads to one of the bridges connecting with Amager and the mainland.

Besides its staple product, gas, the Maersk Refinery will produce chemicals for industry and, as a beginning, the "Danske Spritfabrikker" have moved their Copenhagen factory to a neighbouring site, where they will use gas from the refinery to manufacture alcohol for technical use.

Prøvestenen, as has been already stated, has a capacity at present of 60 million gallons, with a land reserve for another 45 million, which means that with a triple turnover per year, it would be possible to handle an annual import of about 1,300,000 tons.

It was originally thought that Prøvestenen, as it now stands, would be sufficient for the immediate future, but already it has been found necessary to extend the facilities. In the autumn of 1955 a new reclamation was started on the north-western side of the harbour.



General view of the islands of Provestenen and Amager.

A Bonded Warehouse Fire

Its Cause and Lessons Analysed*

Damage to the value of more than £350,000 was caused by a fire in the bonded warehouse of Messrs. Hill Thompson & Co. Ltd., Leith, on the 8th June 1955.

Construction and Layout

The premises principally involved and known as Bond No. 4, occupied an island site about 70 × 100 ft. They consisted of two bonded warehouses and a duty paid warehouse. The two bonded warehouses were known as the Old Bond and the New Bond. They adjoined one another and were separated by a stone load-bearing wall which was formerly an external wall of the Old Bond. Most of the original window openings had been filled with brick but some had been enlarged to provide openings, at all levels except the basement, between the two bonds. The openings were protected by double fire-resisting metal covered doors which were all thought to have been closed. The duty paid warehouse, which was not affected by the fire, adjoined the south-east wall of the Old Bond. Another bonded warehouse (No. 27) was involved in the fire, but not seriously damaged.

The Old Bond was a building of four storeys, basement and attic. The walls were of stone and were load bearing. The roof was pitched, close-boarded and slated. In the attic was a ceiling of lath and plaster. All the floors were of wood on wooden joists supported by wooden beams and posts. The internal partitions were of stone and had unprotected openings at ground and upper levels. An enclosed stone staircase and an open hoist, both with unprotected openings, connected all levels of the building.

The New Bond was a five-storey building with a basement. It was of steel frame construction with brick panel walls and a flat, asphalt-covered concrete roof. Floors were of concrete carried on unprotected steel joists on unprotected cast-iron columns. Internal partitions were of brick and timber throughout the building. There was a hoist from the basement to the second storey; the shaft was enclosed in brickwork but the openings were unprotected.

The New Bond where burning spirit flowed down the lift shaft.

The windows of both buildings were protected by iron bars, close-mesh fixed wire guards and thick wooden shutters.

Both bonds carried large stocks of whisky. The Old Bond contained cellar storage in the basement, vats on the ground storey, and whisky in casks on all the upper floors including the attic. The New Bond contained bottling, corking, labelling, washing and packing equipment in the basement and the ground storey, vats on the first storey, and whisky in cases and casks on the three remaining storeys.

The warehouse was in a congested area and was surrounded by grain, wine, spirit, methylated spirit and paint stores, with an estimated total value of £5,000,000. Bond No. 27, which was ignited by radiated heat, stood only 18 ft. away across Quality Lane.

Cause and Origin of the Fire

The roofs of neighbouring buildings were covered with grain dust from a nearby fodder mill. The dust was impregnated with incompletely burned oil from the chimney of an oil burner in Messrs. Hill Thompson's premises, and it is thought that similar material on the south-east corner of the roof of the Old Bond was ignited by a spark some three and four hours earlier from an unattended fire in a chimney about 35 ft. away. A sample of the dust was found to burn slowly and steadily, giving off heavy, oily fumes.

Although the fire-resisting doors at the top storey were open at the time of the fire, the barrels stored there sustained no damage.

The first signs of fire were wisps of smoke noticed at about 4.30 p.m. at the top of the hoist shaft in the Old Bond. Employees entered the attic and found a thick layer of smoke. They tried, without success, to locate the fire and attack it with portable extinguishers, but were soon driven out by the heat. At this point the manager was called and he immediately summoned the fire brigade. The call was received by the South-Eastern (Scotland) Fire Brigade at 4.44 p.m.

Spread of Fire

When the brigade arrived the fire was already burning fiercely above the plaster ceiling in the attic and firemen were forced to withdraw to the storey beneath. It was then noticed that burning spirit was flowing across the floor and down the lift shaft. It also flowed through an opening in the separating wall between the two bonds under fire-resisting doors and down the lift hoists into the basement and ground storey of the New Bond, causing a number of fires.

Flames 100 ft. high burst from the roof of the Old Bond, radiating intense heat which threatened surrounding properties and ignited the north-east corner of Bond No. 27, a five-storey building containing 6,500 casks of spirits. At the same time burning spirit flowed into the surrounding lanes and streets and increased the danger to other buildings. In addition, 22 small fires, widely distributed over the roof area, occurred in Bond No. 27.

* Reprinted from the Fire Protection Association Journal, January, 1956.

A Bonded Warehouse Fire—continued

The area in which the fire occurred was a congested one: firemen found it difficult to manoeuvre. The roofs of nearby premises ignited, but serious damage was avoided.

Fire Fighting

Firemen were forced by the heat to withdraw from the top storey of the Old Bond almost immediately and it was soon clear that the building could not be saved, so efforts were concentrated on preventing the fire from spreading to neighbouring property.

The fires in Bond No. 27 were at once attacked, but were not brought under control until the extinction of the spirit burning in the streets released additional jets and men.

No sooner were the fires in Bond No. 27 under control than smoke was seen coming from the windows of the New Bond.

The fire brigade had been informed that the fire-resisting doors between the Old and the New Bonds were secured, but, on entering the New Bond at the ground storey found that burning spirit had flowed under the fire doors and had ignited about half the contents of the ground storey. When the fires had been extinguished an examination of the whole building was made. This revealed that the double fire-resisting doors in the top storey were open but that the fire had not yet reached the casks of spirit stored there.

Owing to the narrowness of the lanes and streets surrounding the warehouse the firemen were in constant danger from falling debris and orders to withdraw from Quality Lane were given. These had scarcely been carried out when part of the roof and a section of the wall of the Old Bond fell into the roadway.

Fire caused by burning spirit which had run down the lift shaft broke out in the basement. The fire was extinguished after an arduous struggle, and at 9.07 p.m. the stop notice was sent. Damping and cooling operations were continued until 5.08 p.m. the next day. Fifteen jets supplied by seven pumps had been engaged in the fire. Three firemen were injured.

Damage

The structure and contents of the Old Bond were completely destroyed, and the wall dividing it from the New Bond was severely damaged and weakened. A large quantity of whisky in the New Bond was destroyed and machinery was damaged by heat, smoke and water. About a fifth of the roof of Bond No. 27 was damaged by fire.

Lessons of the Fire

Had the brigade been called immediately, the fire might not have spread so widely. In previous fires in spirit stores sudden bursts of flame from window openings have created difficulties for the fire fighters. The windows in these premises were protected by wire guards and thick wooden shutters and were of great help in reducing radiation and preventing these sudden bursts of flame. Without the protection given by these windows, the position of the firemen in Quality Lane would have been untenable and the danger to Bond No. 27 greatly increased.

The cause of the fire suggests that occupiers of buildings near premises where combustible dusts are dispersed into the atmosphere in large quantities should frequently examine roofs and gutters and remove deposits.

The construction of sills at door openings would have prevented the spread of fire through burning spirit flowing under those fire-resisting doors that were closed and down hoist wells. Failure to close the fire-resisting doors on the top of the New Bond might have resulted in further serious damage.

Oil Pollution in Danish Waters

The Danish Folketing has passed a Bill making it illegal for ships to discharge oil in Danish territorial waters. This is in accordance with the International Convention for the Prevention of Pollution of the Sea by Oil, signed in London in May 1954, and already ratified by a number of States. The Government is to subsidise the construction of special installations for waste oil disposal.

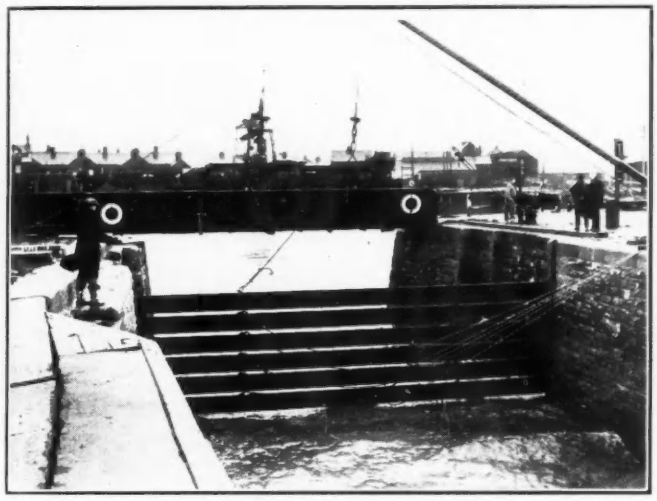
Reducing Harbour Swell at Exmouth

Effective Use of Removable Steel Gate

The port of Exmouth on the River Exe was constructed ninety years ago by excavating a suitable site in the banks of the river. The area of the tidal basin thus created is about four acres, and the entrance is by way of a short canal of about 130 yards long between piers and with a minimum width of 35 ft. The dock admits ships up to 700 tons d.w., if not exceeding 180 ft. long by 28 ft. beam by 14 ft. draft at springs and 11 ft. draft at neaps.

The trade of the port has increased steadily since the war and is now running at the rate of 56,000 N.R. tons per annum. This increase has been achieved in the face of a disaster which occurred at the end of the war just when the port was preparing to resume normal activity.

In the winter of 1945-46 a severe storm washed away a large proportion of the spit of land on the other side of the estuary known as Dawlish Warren, with the result that Exmouth, which had hitherto been well sheltered from sea waves and swell, found itself exposed particularly to waves from the South-East. The consequences of this were particularly severe when a S.E. gale



View of Steel Gate in position at low water.

coincided with spring tides. Not only was the entrance to the dock made hazardous, but there was considerable erosion of beach on the north side of the North Pier, which threatened to damage the dock property on that foreshore. Furthermore, the incursion of swell into the basin during storms was a serious handicap and resulted in much surging of ships and breakage of wires.

This crisis in the affairs of the Exmouth Dock Company was solved in an ingenious and economical manner by the Manager, Mr. G. M. Young, as follows. The walls of the entrance channel fortunately contained slots originally provided for a caisson. A wave barrier was constructed to fit into these slots, and to be placed in them when circumstances warranted.

The barrier consisted of seven lengths of Larssen sheet piling laid on edge. Each pile was fitted with specially designed mild steel brackets, whose purpose was both to make the pile stand upright in the slots and to provide a four-inch gap between one pile and the next. Each pile weighs 15.5 cwt. and is fitted with wire strops for handling. The gap between each pile was arranged in order to relieve the pressure of the heavy swell on the barrier; a portion of the surge washes through the gaps, but the wave motion is broken.

When the barrier is required, or its use in the next few hours can be foreseen, the piles are lifted one by one, by means of a derrick and hand winch, and dropped into the masonry slots. The total height of the barrier is 11 ft., and the barrier as a whole is positioned so that some swell from an extra high tide can slop over the top, while there is clearance of six feet between the bottom of the barrier and the floor of the canal. This latter clearance is provided to facilitate ebb and flow in the basin, which takes place below the surface and hence in a zone in which there is less wave energy.

Installing the barrier takes about half an hour. It is left in position from half flood tide until one hour after high water. As soon as the ebb commences in the river, the south-easterly swell dies away.

The resultant wave and swell inside the dock is between 80 and 90 per cent. of what it was before the barrier was constructed. The cost of the entire installation was approximately £240, and the operating cost, that is for placing and removal, averages £2 10s. each time the emergency arises.

While the barrier described above has solved one of the three problems arising from the destruction of Dawlish Warren, there remains outstanding the problems of navigation in the entrance in heavy weather and the erosion of the foreshore referred to above. Their solution calls for a reduction of waves in the main channel outside the harbour, and the installation of a pneumatic breakwater is now under consideration.

Symposium on General Cargo Handling

Meeting at the Institute of Civil Engineers

On March 20th last, a Symposium of four Papers on general cargo handling was held in London by the Maritime and Waterways Division of the Institution of Civil Engineers. Synopses of these Papers are as follows:

"The Design of Ships from a cargo-handling point of view"

by J. A. H. Lees

The subject is dealt with generally, and primarily from the point of view of the ship designer.

A conventional type of cargo liner is used as a basis to discuss certain fundamental design features and to point out where these are controlled by regulations or necessity. The possible effect on the cargo arrangements of incorporating in the design accommodation for a larger number of passengers is indicated.

The usual method of handling general cargo is described, and it is explained that the process of moving cargo from the quayside to its stowage position in the vessel is not the only problem to be considered.

It is noted that considerable loss of cargo space is occasioned when it is necessary to provide insulated chambers and also that the maximum utilization of cargo space depends on the design of the ship, the type of cargo, and the stowing of that cargo.

It is suggested that under present circumstances speeds for loading and discharge may be influenced more by the port facilities than by the design of the ship; also, that whereas the layout and equipment for a general cargo liner may not materially alter, new trades, or the stabilization of bulk trades, may call for new ports arranged for automatic handling and new ships would then be designed accordingly.

"Civil Engineering Structures"

by N. A. Matheson, M.I.C.E., M.I.Mech.E.

In this paper attention is drawn to some aspects of the layout and construction of dock roadways and railways, quayage, transit sheds and warehouses, with special regard to their effect on handling general cargo.

Some of the requirements for efficient road, rail, and shed working are set out briefly; the Figures given in the Paper are only intended to illustrate in very general form the main features mentioned.

The necessity to utilise space to the utmost advantage is a primary factor in the layout of dock estates, and it is pointed out that the best engineering design must on occasion give place to other considerations which may equally influence the prosperity of an undertaking; particularly so in sheds, where ease of operation must be related to the cost of the facility provided and its revenue-earning capacity.

Symposium on Cargo Handling—continued

Since so much depends on the type and volume of goods handled, each port, and even each berth,, may call for its own particular layout. Considerations of the loadings imposed by buildings, roadways, rail tracks, cranes, and other mobile appliances also play an important part in the design of quay structures.

The Paper can discuss only the main essential requirements for the handling of the more normal types of general cargo which pass through British ports today.

"The Supply & Maintenance of Mechanical Equipment"

by J. C. Shire, A.M.I.Mech.E., A.M.I.N.A.

The Paper deals with the method of selecting mechanical-handling equipment, and illustrates some modifications carried out on standerd production machines to make them suitable for port work.

Reference is made to running costs of various types of equipment, to chain gear, and to the design of hand and lifting appliances.

The problem of maintenance, attendant on the extensive use of mobile handling equipment, is dealt with by describing a typical organisation which has proved itself effective in operation.

" Handling of Port Traffic "

by E. S. Tooth

The subject is particularly interesting at the present time because a revolution in cargo-handling methods it taking place. The main impetus to this revolution arises from the world-wide need to turn ships round quickly. Shipping interests are much concerned with the proportion of their outlay spent on ships in port.

Speedy loading and discharge involve the need for speedy handlling of goods into and out of port premises. Transit sheds particularly must always be cleared as quickly as possible. Thus, shed appliances must be as efficient as quay cranes and ships' purchases.

The two most important appliances which are eliminating delays on the quay are the mobile crane and the fork-lift truck. To operate these machines speedily and safely, drivers must be keenly aware of certain principles new to port operating work. The employment of these appliances makes for speedier working, saves space, reduces arduous labour, and often lessens pilferage and breaking risks. It also involves, however, alterations in layout and design of quays, transit sheds, and warehouses.

Many of the benefits mentioned could not have accrued without the introduction of dock pallets and the method employed at modern mechanised berths often revolves round the employment of these tools. This way of working is closely related to the unit-load method of transporting goods, which is expected ultimately to become universal. Goods would then travel as unit loads from production line or shippers' premises to foreign destination without need arising at any time for individual packages to be man-handled. When this development occurs, ports so modernised will find no difficulty in handling the new type traffic.

In view of the importance of this subject to many readers of " The Dock and Harbour Authority " it is hoped to publish extensive extracts of these Papers within the next month or two.

Plan for Philippine Ports Authority

A Bill has been presented to the U.S.A. House of Representatives, for consideration during the Third Congress, for the purpose of setting up a government agency to be known as the Philippine Ports Administration.

Under the provisions of the Bill it is the duty of the Administration to be responsible for the maintenance and improvement of all existing ports and for the development and construction of new ports. It would be responsible for lights and navigational aids and would supervise pilotage and operate ship-to-shore communications. It would have the power to investigate marine accidents and to inspect hulls, boilers and other constructional features of Philippine vessels. The Administration will have the right to assess and collect charges or fees and to issue, through the Central Bank, bonds to finance the development of ports, provided that the aggregate amount does not at any time exceed 10 million pesos.

APPOINTMENTS VACANT

THE MANCHESTER SHIP CANAL COMPANY

The Manchester Ship Canal Company invite applications for the appointments of Assistant Civil Engineers and Design Engineers on the established staff of the Chief Engineer. Scale of salaries £740 (at age 28) rising by annual increments to £1,200 at 41.

Candidates should be Corporate Members of the Institution of Civil Engineers, or hold equivalent qualifications and should have experience in the following:

(a) **Assistant Civil Engineers:**—Design, Specifications, construction and maintenance of civil engineering works. Harbour and dock experience is preferable but not essential.

(b) **Design Engineers.**—Wide experience in the design of civil engineering structures and the preparation of specifications, contract documents and bills of quantities. Harbour and dock experience is preferable but not essential.

Successful applicants will require to become members of the Company's Contributory Superannuation Scheme.

Applications, stating age, qualifications, and experience should be addressed to the Chief Engineer, Manchester Ship Canal Company, Ship Canal House, King Street, Manchester, 2.

PORT OF ADEN TRUST

The Board of Trustees of the Port of Aden invite applications for the post of Assistant Port Engineer. Young man preferred. Applicants must be corporate members of the Institution of Civil Engineers. Previous experience of harbour works is desirable. Salary £1,250 x £50 to £1,750 per annum. For A.M.I.C.E. starting salary £1,350.

Free unfurnished quarters are provided and free medical attention for the employee. A contributory medical benefit scheme covers dependants for a small charge.

Option is available to enter the service on short term contract for five years, comprising two tours each two years abroad, followed by six months leave, with a gratuity of 10 per cent. of final annual salary for each year of service, or alternatively joining the Permanent Service on probation. Option is also given of entering the Permanent Service of the Board subject to the Board's approval at the end of the five years contract.

Full details and application forms may be obtained from Aden Port Trust Consulting Engineers and Agents, 1, Lygon Place Grosvenor Gardens, London, S.W.1.

BRITISH TRANSPORT WATERWAYS invite applications for Assistant Engineer for Planning and Construction of New Works in their office at Gloucester. Salary range £900—£1,100 p.a. (salary ranges at present under review) with Superannuation Scheme and certain Privilege Travel Facilities. Applicants must be Corporate Members of the Institution of Civil Engineers; some experience in Design and Construction of Marine or River Work will be an advantage. Applications stating qualifications, experience, present salary, to be addressed to Staff and Establishment Officer, 22, Dorset Square, London, N.W.1, by 31st March, 1956.

WANTED.—Engineer holding 1st Class B.O.T. Diesel certificate as Chief Engineer of a vessel trading in the Indian Ocean.
For further particulars apply to: Diego-Agalega Shipping Co. Ltd., 9, New Moka Street, Port Louis, Mauritius.

SITUATIONS WANTED

DREDGING MASTER.—Master Foreign going, requires post with Dredging Company. 24 years Drag, Suction, Grab, Bucket, Iraq, India. Some administrative experience, age 55. Excellent health, first class references. Box No. 182, " The Dock and Harbour Authority," 19 Harcourt Street, London, W.I.

FOR SALE

OFFERED.—Steel Storage Buildings, Hangars, Go-downs, Tropical Sheds, Factories, etc. Write BELLMAN HANGARS LTD., Hobart House, S.W.1.

WANTED

WANTED.—Second-hand 5-ton diesel locomotive shunting crane (standard gauge) in good running order. Reply to the General Manager and Secretary, Tyne Improvement Commission, Bewick Street, Newcastle-upon-Tyne, 1.

WANTED TO PURCHASE

BUCKET DREDGER

of one cubic yard bucket capacity

Reply to Box No. 181, " The Dock and Harbour Authority," 19 Harcourt Street, London, W.1.